SUMMER 1989

AIR FORCE JOURNAL of LOGISTICS

SPECIALS
- Air Base Vulnerability
- People—Equipment—Combat Capability

AFRP 400-1

VOL XIII NO 3

AIR FORCE JOURNAL of LOGISTICS

SUMMER 1989

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COULD THIS HAPPEN TO OUR AIR BASE?

ON THE FRONT COVER: This scene portrays what our air base could look like under attack. Just how vulnerable are our air bases and what are we doing about it? See back cover and pages 1 thru 7 for more photos and articles.

SPECIAL: AIR BASE VULNERABILITY: THE HUMAN ELEMENT

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Purpose The *Air Force Journal of Logistics* provides an open forum for the presentation of issues, ideas, research, and information of concern to logisticians who plan, acquire, maintain, supply, transport, and provide supporting engineering and services for military aerospace forces. It is a non-directive, quarterly periodical published under AFR 5-1. Views expressed in the articles are those of the author and do not necessarily represent the established policy of the Department of Defense, the Department of the Air Force, the Air Force Logistics Management Center, or the organization where the author works.

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Editor's Note: This first article discusses the vulnerability of the air base during SALTY DEMO and what needs to be done in the future to fight and survive. The second article is a news release which reports on READINESS CHALLENGE, a recent exercise where AF Engineering and Services personnel used their skills in a warfighting environment. This is just one initiative to ensure that our bases will not be so vulnerable.

Air Base Vulnerability: The Human Element

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An often cited maxim for the military leader is General Giulio Douhet's statement, "Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after they occur." During the brief history of air power, American air forces have operated from secure bases. In Vietnam, air bases occasionally came under attack from mortar fire and sapper raids, but only during the Tet offensive of 1968 did any of our air bases (Tan Son Nhut and Bien Hoa) experience battalion strength attack. (7) Our airfields were usually sanctuaries. For the airman, combat occurred in the air—not on the ground.

Defeat or cripple the air warrior's base of operations and you defeat or cripple the air warrior.

As we enter the last decade of the twentieth century, the vulnerability of the air base is exposed. SALTY DEMO has improved our perspective. This two-week exercise at Spangdahlem Air Base in the Federal Republic of Germany in 1985 was "a sobering demonstration of the synergistic chaos that ensues when everything goes wrong at the same time." (7:50) In a simulated moderate attack on the base, almost one-third of base personnel were casualties. Simulated fires burned uncontrollably and unexploded ordnances were to be found throughout the base. (7)

SALTY DEMO underscored what Soviet planners already knew: the air base is "the Achilles' heel of air power." (6:47) Soviet offensive strategy is to defeat air forces on the ground. (3) The Soviet military is equipped and organized to achieve this objective. Special operations forces *(spetnaznacheniya)*, or Spetsnaz units, can conduct surprise attacks in rear areas to shock air base personnel and disrupt air base operations. (5) Airfield attack munitions delivered by missiles and aircraft can threaten and seriously damage most European theater air bases. (6;9) Furthermore, Soviet main forces attacking in mass and successfully achieving a rapid advance would soon envelop prime target air bases.

But the lessons of SALTY DEMO are not just for those who stand ready in central Europe; nor are the lessons limited to high-intensity conflict. Our air bases are also vulnerable to those who would do harm to our nation and its allies through terrorism, "warfare on the cheap." We have experienced terrorist attacks on our air bases. There is no reason to expect them to stop, but there are reasons to expect them to increase in frequency and lethality. Air bases at home and abroad are vulnerable. Across the spectrum of conflict, from low-intensity warfare and terrorism to full-scale high-intensity conflict, the air base and its personnel have a higher profile. Defeat or cripple the air warrior's base of operations and you defeat or cripple the air warrior.

Some of the implications of the changing air base environment are clear and provide an impetus for technological innovation and tactical reassessment. Other implications are not as clear and potentially more intractable. Significant to the staying power and synergy of the air base is the human element. It is the men *and women* of our air bases who must be able to fight, survive, and recover to sustain air operations. To do so, air base personnel must be organized, trained, and equipped for the combat environment.

The vulnerability of our air bases and the need for Air Force support personnel to recognize and be prepared for a combatant role require a fundamental shift in the organizational culture of our Air Force and the individual attitudes of Air Force personnel. Wearing a gas mask for a few hours twice a year does not prepare one for a total chemical environment. Firing a weapon in basic training does not prepare one to augment special police forces defending a base perimeter. Boy or Girl Scout first-aid training does not prepare one for treating a buddy with missing limbs. Psychology 101 does not prepare one to handle the debilitating effect of battle shock. Training exercises that do not push men and women into 24, 28, or 36 hours without sleep do not prepare them for the problems of visual hallucinations, impaired mental processes, reduced short-term memory, and impaired ability to communicate—characteristics of human behavior in continuous operations.

This change in the soul of the support force and character of the Air Force will not be easy. We are a dedicated organization of professionals who accomplish our duties in support of those who fly and fight. We are the world's finest at what we do—but few of us see what we do in support of our fliers as involving combat. We have a force that largely sees itself as noncombatants. This is nothing new. In 1941 Prime Minister Winston Churchill observed:

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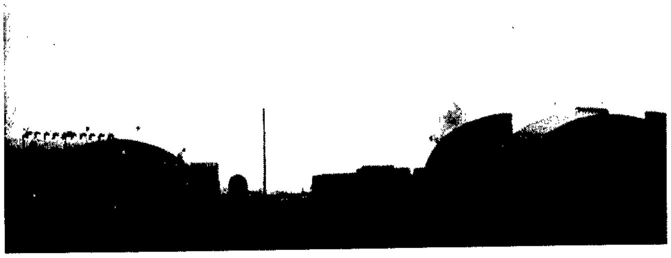
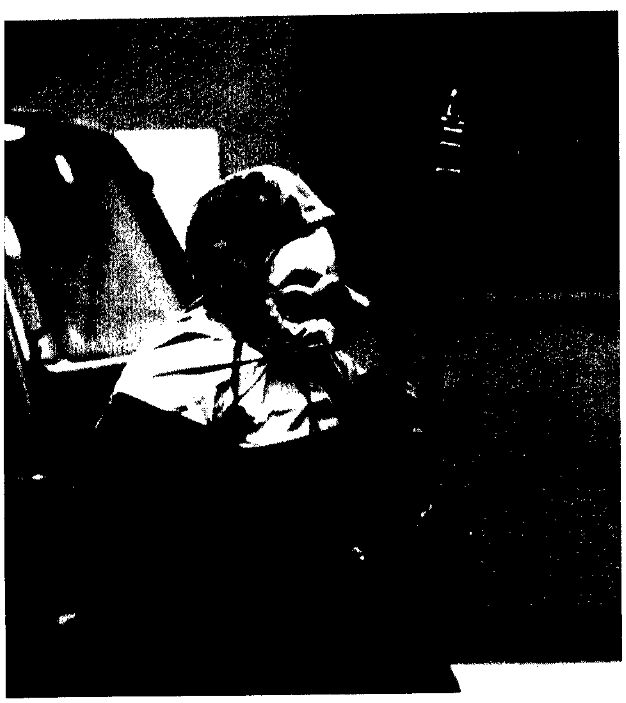


(1) Immediate aftermath. The fog of war. Time to recover.

(2) Damage assessment.

(3) Surveying the damage.

(4) Defending the air base perimeter.



(5) The "fighting air-groundsman."

(6) First aid.

SALTY DEMO

> The enormous mass of noncombatant personnel who look after the very few heroic pilots, who alone in ordinary circumstances do all the fighting, is an inherent difficulty in the organization of the (British) Air Force. (8:8)

Churchill wrote these words to British Air Minister Sir Archibald Sinclair in 1941 after British airfield personnel at Maleme, Crete, offered little resistance and quickly succumbed to a German attack. Churchill concluded:

> Every airfield should be a stronghold of fighting air-groundsmen, and not the abode of uniformed civilians in the prime of life protected by detachments of soldiers. (8:8)

These words warrant a place on walls in hangars, offices, and dining halls throughout the Air Force. These words warrant a place in the education and socialization of every new officer and every young airman.

Major General George E. Ellis, while Director, Engineering and Services, HQ USAF (now retired), echoed these observations, stating that "air base defense is everyone's job" (9:59) and all personnel should be trained in firefighting, medical care, and defensive infantry tactics. He viewed the air base as being comprised of many elements (people, equipment, supplies, etc.) that must combine "synergistically" for air power to be effectively employed. (8:9) *Synergy* is a critical attribute for any military force that is to be effective in combat. (11) Defined as the ability of a force to produce an effect greater than the sum of its individual components, synergy can be enhanced by those intangible factors often summarily discussed by military historians as "fighting spirit," factors such as cohesion, leadership, discipline, and training. These same factors also determine a second critical attribute of an effective fighting force: *staying power*, which is the ability of a force to persist under the most adverse and trying conditions—resoluteness. (11)

Synergy and staying power are not concepts at the forefront of our professional dialogues although they are inherent in our logistical operations. More often we speak of productivity, "bang for the buck," or quality. These are the terms of our realities: the budget battles, the necessity to "do more with less," and the need for managerial effectiveness. The management of resources is the central theme woven into the fabric of professional military education. SALTY DEMO was about synergy and staying power. SALTY DEMO spoke to another reality.

Based on the Israeli experiences in 1973 and in Lebanon, combat shock could initially account for over 50% of all casualties.

The intensity and lethality of modern combat is far removed from World War II. The effect of a Soviet attack on unprepared, "noncombatant" Air Force personnel could be devastating. An air base under Soviet attack would be a place of death, dying, traumatic casualties, and unimaginable violence and destruction. It would be a spectacle of immense proportions and horror. Top priority air bases could expect a rain of fuel-air explosives delivered by Scud B missiles, each comparable to low-yield nuclear weapons. (1) Based on the Israeli experiences in 1973 and in Lebanon, combat shock could initially account for over 50% of all casualties.

Although combat shock casualties can be expected to produce enormous losses in an air base attack using modern weapons, general knowledge about combat shock, its symptoms, its treatment, and its prevention is not common among Air Force personnel. The Israeli experience is clear: In combat situations of high lethality and intensity, combat shock casualties emerge rapidly and can render significant numbers of personnel unable to function within a few hours. (2) The Arab-Israeli War of 1973 demonstrated that combat shock is more a function of intensity than duration and that support personnel are more susceptible to combat shock than troops trained for combat. Compounding our lack of knowledge are beliefs with no basis in fact, such as battle shock is just another name for cowardice. Given combat of sufficient intensity, lethality, and duration, there is no human being who cannot be broken.

Combat shock is a temporary psychological disorder brought on by feelings of overpowering helplessness, typically associated with initial exposure to traumatic death, and usually characterized by mental withdrawal, unresponsiveness, and confusion. (10;12) Treatment is based on four principles: immediacy, proximity, expectancy, and simplicity. Treatment should begin as soon as possible and be conducted near the unit so the airmen can return to the unit at the earliest reasonable time. The airmen should be treated as airmen, not as patients, and treatment should be simple. The purpose is not intensive psychotherapy but simply to help each airman get his or her act back together and rejoin the unit. (4) The keys to reducing combat shock casualties are cohesion and leadership. In those units where bonding is high, where teamwork is strong, and where people care for each other, the group psychologically sustains its members. Likewise, those officers who know their jobs, and whom the troops view as competent and trustworthy, are the leaders who give their airmen faith and hope to persevere. The Israelis have found that the units which are most effective in combat and which sustain the fewest combat shock casualties are those with high morale and trust in their commanders. (2)

Our air bases will be as vulnerable as our people.

To fight, survive, and recover to sustain air operations, air base personnel are going to need the synergy and staying power that can only come through leadership, cohesion, discipline, and training. The United States Air Force has never been tested "in a war-fighting environment where our basing structure is seriously damaged and we have to generate sorties while continuously under attack." (8:7) Air base operability initiatives are being developed to make certain our air base facilities are less vulnerable, our equipment is in place and ready, and our defensive tactics are most effective. But in air base defense, as in combat throughout history, it is the human element that will be decisive. Our air bases will be as vulnerable as our people.

Lieutenant Colonel John Ballard is course director for an AFIT graduate course, Behavior in Combat, offered as an elective in the School of Systems and Logistics.

Captain Jon Wheeler is course director for the Air Base Combat Engineering course, a mandatory entry level class for all Air Force civil engineering officers.

Both Colonel Ballard and Captain Wheeler are engaged in research in support of air base operability initiatives.

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READER EXCHANGE

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Transformation of Base Level Quality Assurance Programs

I read with interest the excellent article, "Transformation of Base Level Maintenance Quality Assurance," by Captain Stephen M. Baysinger, in the *Air Force Journal of Logistics* (Spring Issue), and I couldn't resist the urge to communicate what, in my opinion, might be an interesting footnote to the article.

From 1981-1983, I was assigned as a maintenance team chief at the Air Force Inspection and Safety Center (AFISC); and, sometime in 1982, after completing a somewhat uneventful compliance-oriented Functional Management Inspection (FMI) on the Air Force Corrosion Control Program, my maintenance team was searching for an FMI with a little more excitement that could really improve life in the maintenance trenches. I don't remember from where or whom the idea was suggested, but we decided on an FMI entitled "Wing Level Quality Assurance Program." A few months into it, we found our report was taking on a more subjective than compliance-oriented look. But that was exciting because we really saw the wing level quality assurance program in all commands as operating in the dark ages and an anachronism when compared to some progressive commercial aviation quality programs, the best of which was Delta. To find out why they were so successful, we asked their corporate quality assurance experts for ideas.

Midway through the FMI, the subjectivity of our report surfaced as a problem with our branch chief who wanted to stick with the old AFISC FMI formula and keep it more compliance oriented. We overcame this barrier and pressed on. At this point we enlisted the services of the AFLMC and had Lt Col Dave Crippen (Maintenance Directorate) accompany us on a fact-finding trip throughout Europe. He liked what he saw and shared our enthusiasm for the project. From that point on, pieces of the puzzle started fitting together very neatly. However, there were still problems ahead. When we validated our findings with the various MAJCOMs, SAC didn't want to listen since they already felt they had a great quality assurance program (after all they invented it) and no changes were necessary. MAC at first didn't believe us but eventually acquiesced when their MSET confirmed we had some ideas with merit. However, TAC was really enthused since they were in the throes of initiating some progressive ideas in their quality assurance arena and our FMI was treated as "Manna from Heaven."

When we published the FMI results, I received a call from TAC requesting I brief the results to a conference TAC was having on the subject of quality assurance. The call was received a week before I was departing PCS to Travis AFB, California. However, TAC was so enthusiastic about the direction they were taking in the quality assurance world that I took a "red eye flight" from Norton AFB, California, to Langley AFB, Virginia, and briefed the conferees. Our findings really homed in on trend analysis and the lack of a viable computer tracking program which I'd like to believe contributed to the PEAP program. As I stated, my PCS was to Travis AFB where my boss was Colonel Bob Polk whom I eventually succeeded as DCM in 1985. He read the FMI and listened to a lot of ideas on the quality assurance program. He definitely liked what he heard and saw and, as the MAC/LGM, I know he made some successful attempts at upgrading the MAC quality assurance program.

Just thought I'd share this story with you in case you might be interested in some more background on the transformation of Base Level Quality Assurance Programs.

Colonel John J. Baker III
89th MAW
Andrews AFB DC

NEWS RELEASE

READINESS CHALLENGE

MSgt William Miller, USAF
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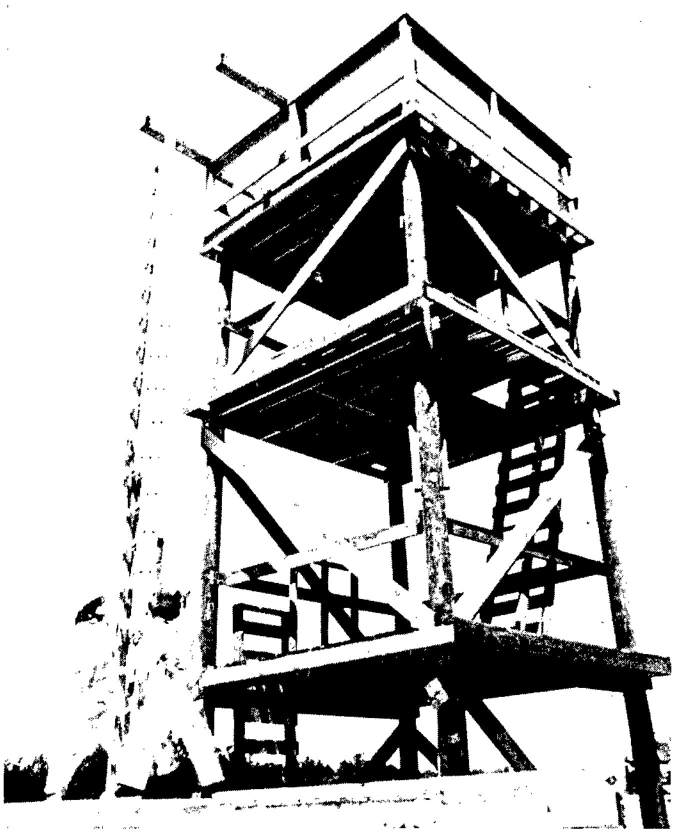
Office of Public Affairs
Tyndall AFB, Florida 32403

Tactical Air Command may have walked away with the Major General William T. Meredith Trophy last May as winner of READINESS CHALLENGE 1989, but the whole Air Force will share in the victory.

Because by honing the skills they will need in combat, the troops who won—and those who didn't—help keep the Air Force ready to *fight* and *win*.

"The idea behind READINESS CHALLENGE is really twofold," said Major Lavon Alston, former commander of Detachment 2, Air Force Engineering and Services Center, who hosted the competition at the Det 2 site, Eglin AFB, Florida. "On one hand, these people are using skills they'll need in wartime. On the other, it helps them keep a warfighting perspective.

"The whole thrust is to give them that motivator to improve their wartime skills at their home bases. We want this to be an incentive for them to go back to their home units and fine-tune their own training programs."



A trio of firefighters position their ladder in the K-12 Hoist event. They will pull the K-12 power saw up the tower and cut through a sheet of plywood. (Photo by SMSgt Zane Zimmerman)

The Dozer event. (Photo by C. Taylor)

This makes a lot of sense to Sgt Timothy Brunori of Tyndall AFB, Florida. He was team chief of Tyndall's 325th Services Squadron team, which trained for almost 11 months to earn a ticket to Eglin as part of the TAC team.

"(READINESS CHALLENGE) keeps us focused on what our real mission is," he said, "and that's to be ready to go to war.

"The insight and the experience we've gotten from READINESS CHALLENGE has made us better trainers for all our people."

The 354th Civil Engineering Squadron, Myrtle Beach AFB, South Carolina, will share the Meredith Award with Tyndall. Together they scored 1,845 of a possible 2,200 points.

Military Airlift Command, represented by the 1606 CES and 1606 SVS from Kirtland AFB, New Mexico, took second place with 1,760, followed by Air Force Systems Command with 1,740.

The Systems Command team came from the 3202 CES and 3201 SVS from Eglin.

Troops battle gas in the SCPS-2 event (for Survivable Collective Protection System). (Photo by A1C Gary R. Coppage)

First Lieutenant Jon Roop, team chief of the Air Force Logistics Command team, won a new award, the Major General George E. Ellis Award,* given to the competitor best exemplifying the spirit of the competition: dedication, leadership, and teamwork.

Lieutenant Roop sees READINESS CHALLENGE as a potential testing ground for new methods and techniques that can be developed within existing restrictions of personnel and equipment.

"I think the intent of READINESS CHALLENGE is to improve on the already proven mode of operations for the various tasks," he said. "You try to come up with new ways of doing the tasks, and when you build a better mousetrap the whole Engineering and Services world learns from it."

The Tyndall Prime RIBS team practices for the Physical Fitness event. (Photo by SSgt Rick L. Fligor)

He also likes how the competition affected the attitudes not only of people on the team but also back in the home unit.

"We tried to build up the professionalism of our up-and-coming airmen. We held open ranks inspections and everyone was called by their rank. It was very formal, but everybody still had a good time.

"Now, since we've been back, the people on the team have been given more responsibility and they've been demonstrating the leadership characteristics that we expect of everybody in the Air Force."

Sgt Robert A. Mayer, Tyndall Prime RIBS team member, prepares the M-2A burner. (Photo by SSgt Rick L. Fligor)

Lieutenant Roop is chief of readiness for the 2852 CES, McClellan AFB, California, who shared the AFLC representation with the 146th Tactical Airlift Wing, Van Nuys Air National Guard, Van Nuys, California.

In designing READINESS CHALLENGE, the Det 2 planners tried to capture in separate events the kinds of tasks Engineering and Services people could find themselves called on to perform in wartime.

The 22 events were divided into three categories: base recovery after attack (BRAAT), force beddown, and a general category that comprised physical fitness and a "fog-of-war" event: No one knew exactly what kind of task it would be until minutes before it began.

The BRAAT events were tasks such as operating firefighting vehicles, marksmanship, and repair of damaged runways, that would be expected to be done following an enemy attack on an air base.

Force beddown tasks included setting up field kitchens, purifying water, and building temporary woodframe tents, things that would have to be done to establish contingency bases.

These events were themselves divided into Prime BEEF (Base Engineer Emergency Force), or engineering, events; and Prime RIBS (Readiness in Base Services), or services, events.

*(Gen Ellis was Director, Engineering and Services, HQ USAF, and is now retired.)

Twenty-person teams competed, representing nine major commands, the Air Force District of Washington, the Air Force Academy, Air University, the Air Force Reserve, and the Air National Guard.

Here are the final standings:

Tactical Air Command, 1845 (354 CES, Myrtle Beach AFB SC, and 325 SVS, Tyndall AFB FL)

Military Airlift Command, 1760 (1606 CES and SVS, Kirtland AFB NM)

Air Force Systems Command, 1740 (3202 CES and 3201 SVS, Eglin AFB FL)

Alaskan Air Command, 1695 (21 CES and SVS, Elmendorf AFB AK)

Pacific Air Forces, 1675 (15 CES and SVS, Hickam AFB HI)

US Air Forces in Europe, 1635 (52 CES and SVS, Spangdahlem AB, West Germany)

Strategic Air Command, 1585 (416 CES and SVS, Griffiss AFB NY)

Air Force Logistics Command, 1385 (2852 CES, McClellan AFB CA, and 146 TAW, Van Nuys ANG, Van Nuys CA)

Air Training Command, 1365 (3345 CES, Chanute AFB IL, and 3700 SVS, Lackland AFB TX)

Air National Guard, 1360 (123 CES and SVS, Standiford Field ANG Base, Louisville KY)

Air University, 1300 (3800 CES and SVS, Maxwell AFB AL)

US Air Force Academy, 1280 (7625 CES and SVS)

AF Reserve, 1210 (507 CES, Tinker AFB OK)

AF District of Washington, 955 (1100 CES and SVS, Bolling AFB DC, and 1776 CES, Andrews AFB MD)

RC '89 was the third READINESS CHALLENGE. AFLC won the first in June 1986 and Systems Command the second in December 1987

SrA Donald F. Inman Jr. (left), and Sgt Donnie L. Eubanks Jr., both of the Tyndall Prime RIBS team, prepare the immersion heater. (Photo by SSgt Rick L. Fligor)

CURRENT RESEARCH

Air University Logistics Research at AWC - 1988-1989

The logistics related papers and projects completed by the students of Air War College during the 1988-1989 academic year are:

"Criteria for Developing a Successful Privatization Project"—Col Walter E. Smith and Col Sel Thomas C. McSwain Jr. (**Winner Society of Logistics Engineers (SOLE) Award**).

"Let's Join the Quality Revolution"—Col Kenton R. Ziegler and Lt Col John T. Twilley (**First Runner-up Society of Logistics Engineers (SOLE) Award**).

"Probable Impact of Space Operations on Air Force Civil Engineering"—Lt Col John W. Mogge Jr. (**Second Runner-up Society of Logistics Engineers (SOLE) Award**).

"Defense Airlift: Getting the Most From our Airline Fleets"—Lt Col Thomas J. Stephenson (**Winner of USAFE Achievement Award**).

"Strategic Mobility and the Decline of the U.S. Merchant Marine"—Lt Col Stephen D. Boyce (**Runner-up USAFE Achievement Award**).

"Combatting Low-Intensity Conflicts in Latin America: The Engineer's Role"—Lt Col Jack T. Baker.

"Training the Weekend Warrior in the Core Automated Maintenance System"—Col John J. Crawford.

"Logistics: The Soviet's Nemesis to Conventional War in Central Europe"—Lt Col Gilbert H. Edmondson.

"The Global Positioning System"—Lt Col Mark J. Fischer.

"Aircraft Battle Damage Repair 2000: Will it Become the Logistics Center of Gravity by the Year 2000?"—Lt Col William R. Foster II.

"Mission Support Squadrons: A Look Into the Future"—Lt Col Donald K. Grandia and Lt Col Wanda C. Wood.

"Orbital Servicing: Issue or Answer?"—Lt Col Douglas Hotard.

"Can the Air Force's Logistics System Sustain a Warfighting Effort in a High-Intensity Conflict?"—Lt Col Albert M. Kluczynski.

"Ambulatory Services Realignment in Air Force Medical Treatment Facilities"—Lt Col Barbara McKenna.

"Congressional Criticism of Air Force Weapons Acquisition Programs: What Can the Air Force Program Manager Do?"—Lt Col Nathan B. Mills.

"Combat Support Doctrine: Guidance or Hindrance?"—Lt Col Dennis L. Reynolds.

"The Tredegar-Logistical Support in the American Civil War"—Lt Col Ted J. Squyres.

"Executive Self-Assessment and Development in the United States Air Force"—Lt Col Todd I. Stewart.

Loan copies are available through the Air University Library, Interlibrary Loan Service (AUL/LDEX), Maxwell AFB, Alabama 36112-5564.

The Oil Market and the US Defense Budget

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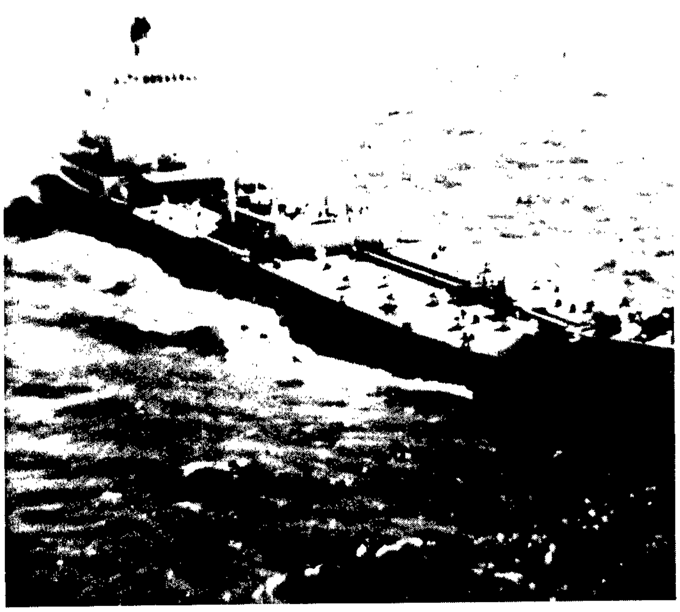
Background

Each day in the United States the Department of Defense (DOD), through its Defense Fuel Supply Center (DFSC), takes delivery of nearly 300,000 barrels (1 barrel = 42 gallons) of jet fuel, enough to supply two or three major airlines. Another 40,000 barrels per day of diesel fuel is purchased to keep the Navy's ships on the move. These fuels are purchased through bulk contracts primarily from the refiners (Arco, Chevron, Exxon, etc.) who manufacture the fuel. Over 60,000 barrels per day of gasoline, diesel fuel, heating oil, and other miscellaneous petroleum products are purchased from local suppliers for the military installations spread around the country. In this case, the local heating oil dealer or gasoline wholesaler supplies the fuel. As a result, the DFSC is the largest single customer for petroleum products in the Free World, with an annual fuel bill that can run from \$4 to \$10 billion depending on market conditions. Virtually all the contracts awarded by the DFSC around the country have a key element in common—a price adjustment mechanism geared to conditions in the local or regional petroleum products market.



Since the oil crisis of 1973, it has generally not been possible to contract at a fixed price for large volumes of petroleum products over a period of time due to the volatility of prices. This price volatility of the modern petroleum market makes a price adjustment clause a necessary fixture in government fuel contracts. Since early 1986, the price of a barrel of crude oil on the New York Mercantile Exchange (NYMEX) has gone from near \$30 per barrel to below \$10 in the summer of 1986; to back up above \$20 in 1987; to below \$13 in late 1988. Crude prices in early 1989 were above \$20 again as a result of OPEC's November 1988 production agreement. A price adjustment clause allows the government and its fuel suppliers to share the risk of this market volatility. Neither party is forced to accept ruinous losses as a result of market forces rendering a fixed contract price untenable. As a result of this system, government fuel costs mirror the price movement in the oil market—when oil prices are going up, so are government costs, and vice versa (Figure 1).

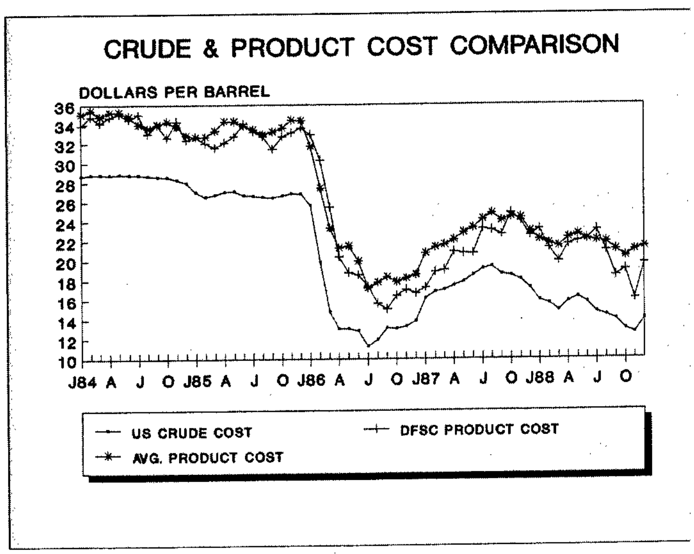


Figure 1.

While somewhat complicated in actual execution, the goal of this price adjustment mechanism is relatively simple—to ensure that, when the government has to buy fuel, it gets the best price available. To understand how this price adjustment system works, it might be helpful to use a simple example. But, before we do that, we will note a few of the basic ingredients of the system.

Price Adjustment Mechanism

Price adjustment methods differ between bulk (refiner) contracts and smaller volume, local-supply contracts.

Government fuel contracts are typically written for either one- or two-year periods—most bulk contracts are one year, while local fuel supply contracts may well be for two years. Prices in these contracts may be adjusted on a weekly or monthly basis—bulk contracts are adjusted monthly while local contracts are adjusted on a weekly basis. The petroleum market index used for price adjustment must be published and available to all parties involved. Each offeror agrees to adjust prices according to the movement of this single "common" index for each fuel in each region in which they offer. For bulk contracts, monthly price data collected by the Department of Energy, and published in the *Petroleum Marketing Monthly* (PMM), are used. By adjusting prices based on the PMM, the DFSC ensures its contract prices move with actual sales prices achieved in the marketplace by commercial firms. For local supply contracts, price indices carried in one of the many petroleum industry periodicals are used. *Oil Price Information Service*, *The Lundberg Letter*, and *Computer Petroleum Corporation* are but a few of the periodicals available. These services contain prices for nearly 300 local markets around the country.

If possible, a published sales price index for an equivalent commercial product will be used to adjust the contract pric the product the government wants to buy. In other word price index for regular unleaded gasoline will be used to adjust government purchase contracts for regular unleaded gasoline. However, since the DOD purchases a number of fuels designed specifically for military use (and so will not have commercial price data available), this is not always possible. In that case, a price index for the most similar alternative commercial product is used. For example, in the case of Navy jet fuel (JP-5), the most similar commercial product is Jet-A, the commercial jet fuel used by domestic air carriers. A refiner capable of making JP-5 would have Jet-A as a viable commercial alternative.

Bulk Contract

Now for an example of how this works. In its bulk contracts, DFSC buys directly from refiners, normally taking ownership of the fuel at or near the refinery and arranging for delivery of the fuel itself. The DFSC has two major bulk purchase programs in the Continental United States (CONUS): East/Gulf and Inland/West. These programs have their contract years offset by six months, thereby easing the administrative burden and ensuring that approximately one-half of domestic requirements are always under contract. In the case of the East/Gulf (an April-March contract year), the DFSC will begin negotiating for contracts in the fall of the previous year, with contractor bids "tied" to the most recent, available issue of *Petroleum Marketing Monthly*, usually August or September. If September has been chosen as the "base" month, a contractor will be asked to submit an as-of-September bid price.

Contract prices will then be negotiated based on a number of factors. DFSC will weigh various supply options for each of its requirements. Through use of a computerized bid evaluation model, each refiner's offer can be "laid into" every requirement location to determine the optimum source for each requirement. This helps ensure contract awards are made based on the lowest "laid down" overall cost. Bid prices will also be evaluated against a regional market range of product-specific sales prices that are determined by the DFSC's own market research staff. Market ranges consist of a low-high range of prices. Prices falling within this range have been determined to be "market" prices. This will give the contract negotiators an idea of how "good" various offered prices are and how much room may be left for negotiation.

At the end of negotiations, contracts are awarded to low offerors, giving the government the best possible product price for the base month used—in this case September. When delivery begins in April, the price the government pays for product on a particular contract will be the September bid price, as adjusted by the difference in actual sales prices between September and April, as reported by the *Petroleum Marketing Monthly* (Figure 2). The goal in this effort is to ensure that the best price at time of contract award remains the best price over the life of the contract. The highly competitive nature of the DFSC procurements usually results in an award price that compares well with the private sector. For example, on jet fuel, DFSC typically ends up paying a somewhat lower price, on average, than the average jet fuel end-user consumer (as reported by the Department of Energy).

Local Contract

Fuel for military installations across the country is purchased

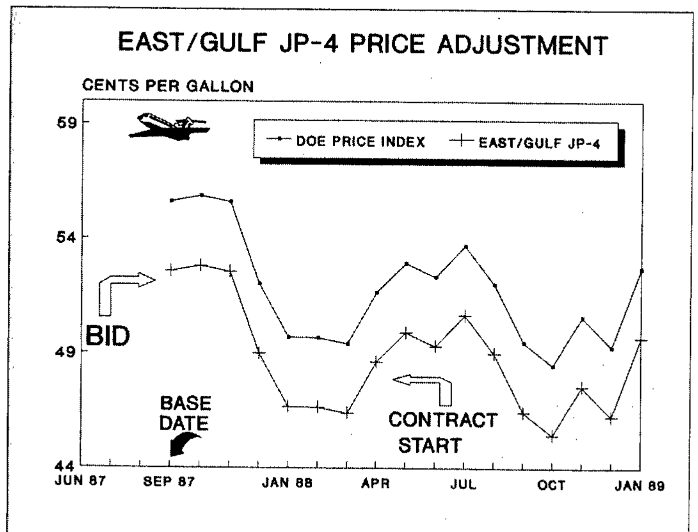


Figure 2.

locally, on a delivered basis. As noted earlier, a local fuel wholesaler would be the typical contractor. These local supply contracts differ from the bulk contracts in that contract prices are not negotiated. Contracts are instead awarded to low bidders as a result of a "sealed-bid" procedure. In order to be considered for an award, bidders must accept all the conditions specified in the contract solicitation, including the price adjustment index. Contract prices are adjusted weekly using this index made up of selected industry periodicals. In this procedure, a base date is established prior to the closing date for bids, and bids are invited as of that date. Contractor bids will be tied to this base index for escalation purposes. Prospective bidders can then research their particular price adjustment index and submit their bids accordingly. At the start of the contract, the contract price will move cent-for-cent with the index price, computed from the base date when bids were made (Figure 3).

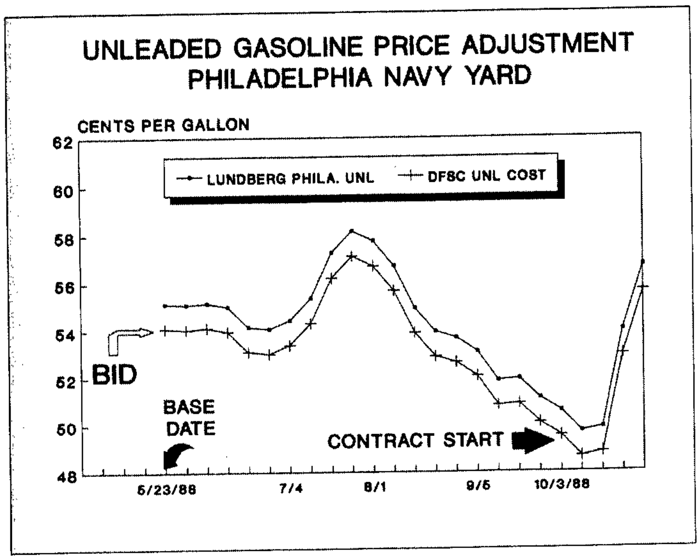


Figure 3.

As noted earlier, these price adjustment mechanisms serve to distribute risk between the government and the contractor so neither party is asked to accept an inordinate risk. The government accepts the risk that market prices fluctuate and its costs will follow suit. However, the government is assured a "market" price throughout the life of its contract. Contractors accept the risk that the price index chosen to adjust contract prices may not exactly duplicate their cost structure. However, if the price index chosen behaves as expected and follows market trends, these risks are minimized.

Fuel Budgets

Since DOD fuel costs will mirror what has become an increasingly volatile oil market, budgeting for upcoming years' fuel expenditures has become somewhat of an inexact science. A crude oil price reduction in 1986 of nearly $20 per barrel resulted in product price reductions of over $.40 per gallon. Likewise, the OPEC agreement of late 1988 sent crude prices up over $7 per barrel and product prices over $.20 per gallon. Even the most sophisticated market analyst could not predict all the various turns the market has taken of late. However thankless the task, a fuel budget still must be made.

When it comes time to put together next year's budget, planners will typically start with a crude oil price forecast. It would be fruitless to attempt to forecast individual costs for each of the myriad of products that the DFSC buys around the world. Instead, a factor is applied to a crude oil price forecast which in effect turns a typical barrel of crude into an aggregate barrel of products. This system will work provided two things happen. First, the crude oil price forecast has to be accurate. Given market activity of the last few years, chances of this happening are not as high as one would like. Secondly, even if the crude oil forecast is correct, the factor used to turn crude prices into product prices may prove inaccurate. This factor is essentially the margin (product price minus crude cost) a refiner will realize in producing products from crude oil. Those unfamiliar with the oil market might assume that the margin of product prices over crude cost remains more or less constant over time. However, this is not the case. Margins can fluctuate by many dollars per barrel over the course of a year (Figure 4.)

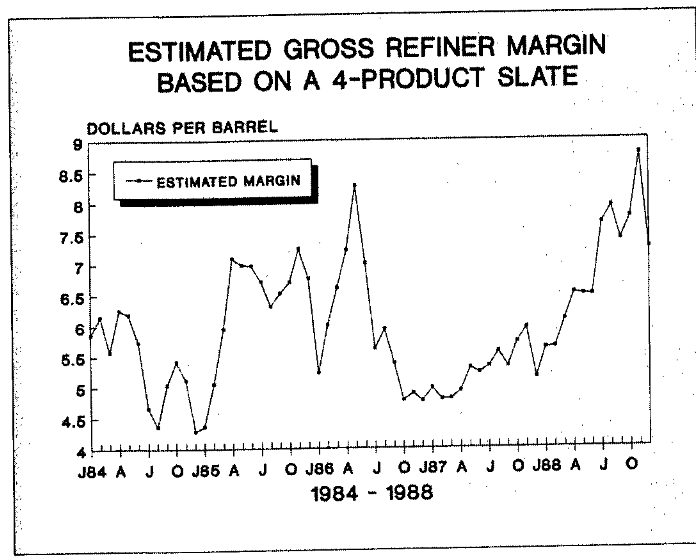


Figure 4.

Refining Margins

The conventional wisdom as expressed by the popular press when reporting on oil prices (such as during an OPEC meeting) is that there is a cent-for-cent correlation between the price of crude oil and gasoline "at the pump." When the barrel (42 gallons) price of crude rises by $2, this is normally translated into a probable nickel-per-gallon increase at the pump ($2 divided by 42 = about a nickel). This sort of logic makes good press, but poor petroleum economics.

What this rationale overlooks is that there are two connected, yet distinct, markets at work here: the crude oil market and the products market. The same events (OPEC production, stock levels, etc.) can have differing influences on these markets. Two recent examples will illustrate this. In early 1987, a combination of a new OPEC agreement and a heating up of the Persian Gulf war pushed crude oil prices over $20 per barrel. At that time, gasoline and distillate (diesel, No.2 heating oil) stocks in the United States were higher than they had been in a number of years. While product prices increased, the increase did not keep pace with crude price increases, so margins fell (Figure 4). In

the summer of 1988, crude oil prices fell as OPEC production soared. At the same time, gasoline demand in the United States was strong. In addition, there were a series of refinery problems in the US which had the potential of reducing gasoline production. Gasoline prices strengthened relative to crude through the summer. At one point in July, gasoline prices were actually rising as crude prices fell (Figure 5). Largely, as a result of this gasoline price strength, 1988 proved very profitable for refiners.

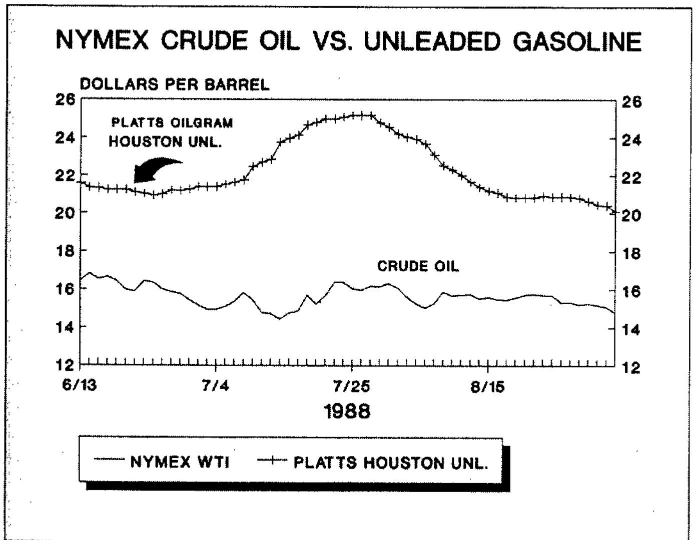


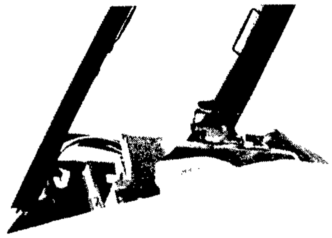
Figure 5.

Major changes in refining margins, such as occurred in 1988, can play havoc with a budget scenario as well as with the "conventional wisdom" regarding how crude and product prices should relate. In July 1987, the average US refiner acquisition cost for a barrel of crude oil was $19.14, while the average wholesale price for a gallon of regular unleaded gasoline was $.605. By July 1988, crude oil cost had fallen to $14.63 per barrel (a decrease of $4.51 per barrel or $.107 per gallon), while the price for a gallon of regular unleaded gasoline had fallen to $.593 (a decrease of $.012 per gallon). Those unfamiliar with the pressures in the gasoline market might well have wondered why gasoline prices were not falling along with crude. And some DOD budget-makers in the Pentagon questioned whether the Department was getting the best price available when fuel costs did not decline as fast as crude oil prices. The reason that did not happen was contract prices for the lion's share of DOD fuel purchases—jet fuel (JP-4) for the Air Force—are adjusted in large part by price movement in the gasoline market (gasoline being the closest commercial alternative to making JP-4). As noted previously, gasoline prices did not fall as sharply as crude oil prices in the summer of 1988.

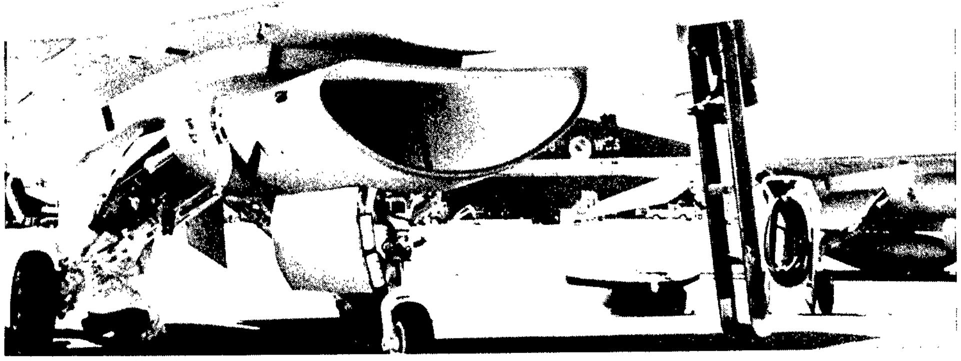
Industry Outlook

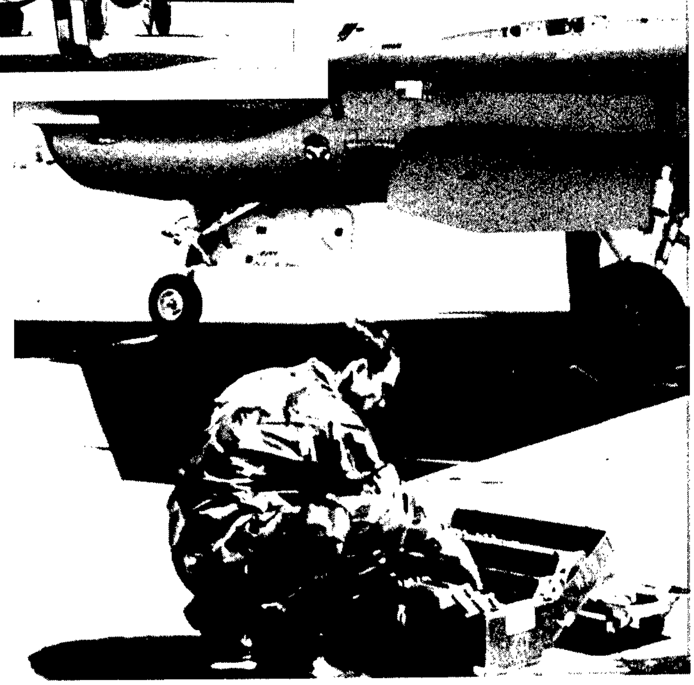
While perhaps not as profitable as 1988, it looks like 1989 will be another good year for the refining industry. Demand for petroleum products continues to grow. Refineries that operated at close to maximum capacity in 1988 have operated at an even higher utilization rate in 1989. Any significant refinery problems of note—and there have been several in 1989—will probably have the same escalating effect on gasoline prices as was seen in 1988. Increasing environmental standards for gasoline have also helped to ratchet up prices.

With product demand growing and profits on the rise, one might expect that the refining industry would be undergoing an expansion. This is not the case. While some existing refineries are undergoing modest upgrades, there are no major new refineries planned for construction in the Continental United States. As a result, US dependence on imports of petroleum products will continue to grow.



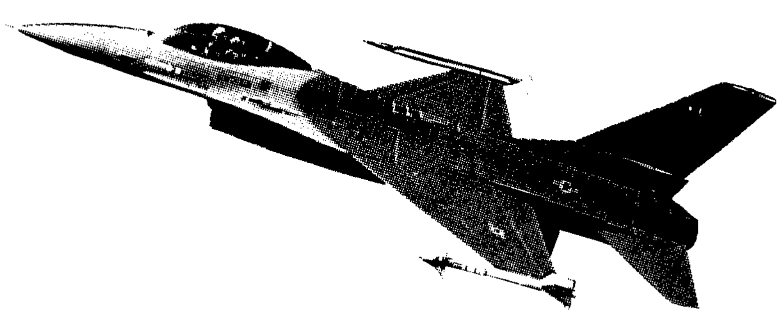
SPECIAL SECTION





"Equipment + Properly Trained People = Combat Capability."

Major J. Michael Wright



IMPACTS Program: Making Weapon Systems More Than Just "Metal on the Ramp"

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Let me offer two equations for your consideration:

Equipment = Potential

Equipment + Properly Trained People = Combat Capability

Without properly trained people in the right place at the right time, our major weapon systems are just so much "metal on the ramp." Trained people and hardware both have a large impact on combat capability, but we have not always thought soon enough about the impact people and their training have on combat capability when we have acquired major weapon systems.

Here is an example: When the F-4 was designed, the radio was placed under the rear ejection seat. Years later, that hardware design decision continues to have significant "people" implications. Fixing the radio requires not only a radio specialist to repair the set, but also an explosives expert to disarm the ejection seat and another technician to remove the otherwise good seat. All that just to get at the radio. By the way, the radio fails an average of every two sorties.

Any good crew chief could have told us that placing the radio under the ejection seat was a poor location. Unfortunately, we never asked a crew chief.

Had the crew chief been asked, he/she would also have been concerned about the length of the training and the man-hours required to complete the task...especially under combat conditions. The process involved in removing the radio from the F-4 is repeated 55,000 times a year. The task absorbs 220,000 man-hours of work and several millions of dollars—and much of the labor and the dollar costs are consumed in removing perfectly healthy ejection seats![1]

The message is clear. Less visible, often overlooked things typically not given enough consideration in the past—like the placement of a radio and the "people" requirements to handle the process—can directly affect our warfighting capability. That is an important consideration, because shrinking budgets and fewer people mean we must squeeze all the combat capability we can out of what we have. There is a new concept called IMPACTS which is designed to help us do that.

What Is IMPACTS?

IMPACTS is an Integrated Manpower, Personnel And Comprehensive Training & Safety program created in the spring of 1988 to influence the design and plan for the fielding of new and modified weapon systems. It replaces and upgrades an earlier Air Force program named RAMPARTS. The use of IMPACTS throughout the weapon system acquisition process (WSAP), especially early in the process, equates to saving millions of dollars, fewer F-4 radio stories, and increased combat capability and reliability. It is actually as much a mind-set as a program. It is a conscientious decision to look at the Manpower, Personnel, Training and Safety (MPTS) factors at the beginning of weapons acquisition and to spend a *few* dollars up front to save *many* dollars later during the fielded life of the weapon system.

Integration is the key to IMPACTS.

Looking at each element of the word IMPACTS more closely should help explain the situation a little better. *Integration* is the key to IMPACTS. Integration is coordination and communication—and giving the boss the big picture with all the facts and trade-offs. MPTS must be integrated across the board throughout the Air Force.

Manpower means authorizations. The number of authorizations depends on such factors as operations and maintenance concepts and personnel skill requirements, and includes specialties—military, civilian, and contractor. Manpower is an increasingly critical area, considering the widening gap between increasing weapon complexity and declining manpower availability. We need to ensure the supportability of our weapon systems, considering the smaller population group from which we can choose and the demographics of the group. Before the turn of the century, the armed forces may find it increasingly difficult to man their ranks as the number of young Americans declines[2] and the requirement for more capable military recruits grows.

Personnel issues have to do with the talents of the individuals who will man the new system and how we will manage them in terms of recruitment, accession, assignment, classification, career progression, and incentive. Personnel planning in systems acquisition is the process of developing the resources necessary to support identified manpower requirements. Successful personnel planning depends primarily on accurate and thorough front-end manpower analysis. The personnel community, especially the Air Force Military Personnel Center (AFMPC), uses this information to perform two major roles: classification of new career fields and Air Force specialty codes

(AFSCs), and personnel support—procuring and managing the personnel resources.

To tie Manpower and Personnel to the rest of the IMPACTS system, we add, "(And) Comprehensive Training & Safety." The system is Comprehensive in that it covers completely all aspects of training and safety. Training encompasses several facets: developing training for new skills necessary to operate, maintain, and support the new weapon system; changing existing training courses in both specialized and career ladder training programs conducted by Air Training Command (ATC) field training detachments; providing MAJCOM and on-the-job-training; and acquiring training equipment needed for the new system. We can ill-afford to cut training dollars first. A good example of how to do it right is the C-17 training program—the aircrew training system will be ready for use 120 days prior to the commencement of operations of the initial squadron in the summer of 1994.[3] Too many weapon systems have reached the field only to be used initially as very expensive training devices instead of front-line, ready-to-go weapon systems.

Safety, of course, is concerned with preventing injuries and the loss of man-hours and equipment that accidents cause. It is important to link safety with IMPACTS in the WSAP, as this provides enhanced safety management support to program managers and focuses greater attention on safety issues as part of the milestone decision process. Air Force Regulation 800-16, *USAF System Safety Programs*, is just one directive that helps ensure safety factors are considered in the WSAP. Safety management and awareness require involvement by all those involved with a systems acquisition or its operation.

How Do We Make IMPACTS Work?

IMPACTS accomplishes its goals through methodologies and procedures called Human Engineering. In aircraft systems, Human Engineering is concerned with task analysis controls, displays, work space, labeling, ingress and egress, communications, hazards, anthropometric data, and trade studies. The "human factor," the crewmember, is ultimately the critical element in a system's performance.

IMPACTS also works by forcing people to consider the "people" factor at every stage of the WSAP. MPTS factors are estimated to account for 30% to 50% of the life cycle costs of a weapon.[4] In a system like the B-2, this impact could be substantial. Large long-range savings could be realized by using IMPACTS.

Using the mind-set of IMPACTS early will enable us to bring a weapon on-line faster and smarter.

The days of being solely concerned with just getting "metal on the ramp" are long gone. Indeed, the most exotic weapon system is just that—metal on the ramp—until we have the people trained to fix the planes, to operate the simulators and training devices, and to man the crews and instructor slots. In other words, we do not really have a weapon system until we have all the support people in place to operate the hardware effectively. Using the mind-set of IMPACTS early, and consistently throughout the WSAP, will enable us to bring a weapon on-line faster and smarter—to get the system up and completely operational as soon as possible at initial operating capability.

The key is to look at the system early when it is just a drawing on a piece of paper. It is easier and cheaper to move a line on a drawing than a piece of metal on an aircraft. Later changes disrupt lots of commitments already made to wiring and metal; inevitably, they have a domino effect causing additional changes and higher costs. So, the earlier an educated decision is made, the better for the system.

Another factor that can affect MPTS is the "on my watch" syndrome. This very expensive problem occurs when the temptation becomes strong to get the weapon system moving along while "I'm in charge," regardless of the effects to the training program or life cycle costs. This syndrome can negate many benefits of MPTS and must be avoided.

Why Do We Need IMPACTS?

Some significant problems in recent years have led to the need for MPTS: weapon systems not designed with future resources in mind, training systems acquired late in the program, and Congress frustrated with getting a larger bill than initially promised. Using IMPACTS in the very beginning of the WSAP will enable the Air Force to provide early estimates of the numbers and types of people; the training resource requirements; and the major safety considerations required to operate, maintain, and support a weapon system. What this means is that with a little communication and coordination early among the players involved in acquiring, manning, flying, and fixing a new weapon, the Air Force can realize significant savings.

As noted, the use of IMPACTS must be applied early in the WSAP and maintained throughout. IMPACTS is not designed to take authority away from the decision makers, but rather to give them more viable information to prevent lost time and money with the end product. It gives decision makers a more complete picture of what a new acquisition means and the costs and trade-offs involved—trade-offs in reference not only to the mission but what it costs to do the mission in manpower, personnel, and training requirements throughout the weapon's life cycle. IMPACTS should also shorten the acquisition process by eliminating costly, time-consuming delays due to design changes made late in the program.

Shortsighted problem solving can cost millions of dollars down the line. MPTS will work to enhance the long-term operational life of a system. It takes a lot of time to bring a weapon system on-line; any program that can decrease the time AND reduce the cost is a program we need today!

How Is IMPACTS Applied?

IMPACTS constraints must be identified in the Statement of Need and Mission Need Statement (MNS) just prior to Program Initiation (POM Approval) and Concept Exploration. The constraints are best applied in the Statement of Need, the MPTS window of opportunity. Instead of being reactive and accepting a weapon system as is, the concept allows us to be proactive and

require the designer to incorporate MPTS and Human Engineering factors into the system "up-front."

Until recently there had been very little incentive for contractors and system program offices (SPO) to consider MPTS in the WSAP. However, Section 2434 of Title 10, U.S.C., now directs the Secretary of Defense to notify Congress of total manpower requirements for a new system. The Law requires cost and manpower computations to include all who will operate, maintain, support, and train—military, civilian, or contracting personnel—on the new system. Manpower requirements must also be computed to consider no increase in manpower authorizations, a very real problem today.

The advanced tactical fighter (ATF) SPO is currently using the IMPACTS process in the development of the new fighter. Working in the design stage, the SPO assesses the implications of MPTS factors and gives feedback to the design engineers. Various trade-offs are discussed—performance versus maintenance for example—and decisions are made. The key is that the decisions are made early, for the longer a decision is delayed, the more it will cost to implement. The costs go up exponentially as each milestone is passed.

It is important to recall that MPTS often accounts for 30% to 50% of the total life cycle costs per weapon system. Applying these percentages to the costs of each system we have flying equates to a pretty hefty chunk of the total Air Force budget! Clearly, life cycle costs of weapon systems are prime targets for budget savings.

The use of IMPACTS should be thought of as "the way we do business."

The use of IMPACTS should not be considered a new program; rather, it should be thought of as "the way we do business." We should ensure that prime contractors are always tasked to provide MPTS analysis, including manning estimates. Unfortunately, MPTS expenditures are hard to measure in money and timed saved. But the benefits are real and the need essential. MPTS suggestions made early in the WSAP bring benefits for everyone in the long run. Early estimations of manpower requirements for a weapon system are intended to ultimately lead to better, more maintainable designs and, more importantly, with high tech systems, to ensure the availability of appropriate numbers of skilled operators and support personnel. The bottom line is IMPACTS enhances unit effectiveness, readiness, and combat capability.

How Do We Measure IMPACTS Benefits?

Benefits derived from IMPACTS are like benefits from safety—they are hard to measure and easy to forget. But maybe this Army example will help show what can be done. The M60 tank was replaced by the more complicated M1 Abrams tank. The M1 has a full-solution fire control system featuring a laser range finder, ballistic computer, thermal-imaging night gun sight, full stabilization, a muzzle reference system to measure gun tube distortion, and a wind sensor. The combat capability of the new tank crews was increased significantly over crews of similar aptitudes in the older M60 tank. Those crews with an above average aptitude increased their scores by 25%. This increase is significant, but consider the fact that those crews with below average aptitude increased their scores by 84%! In fact, below average aptitude crews in the new tank scored better than the above average aptitude crews in the old tank (by half a percentage point).[5] Is this a force multiplier? Is combat capability increased significantly? Does the new tank affect recruiting standards and goals? The answers are: yes, yes, and standards are less restrictive and goals easier to obtain. These are all positive points—beneficial to our combat capability.

The long-term implications are obvious. In the Air Force, IMPACTS benefits will be more readily apparent in years to come. General Larry D. Welch, Chief of Staff of the Air Force, noted in a recent interview that modern weapon systems have increasingly longer lives and "there will be very few major items of equipment 20 years from now that you don't see today." If we design improperly today, we will live with the results for years to come.

How Do We Employ IMPACTS?

IMPACTS requires a few up-front costs to supply the data required and man-hours to work the issues. But it also strengthens the lines of communication that presently exist, adds a few new ones, includes the major commands and Air Staff, and puts everyone under the same guidelines speaking the same language. IMPACTS is a bottom-up approach working on the foundation we already have built from MPTS working groups through the training planning team mechanism. However, more guidance and emphasis are needed to make IMPACTS a viable, cohesive program throughout the Air Force. A recent DOD MPTS Directive has started things going.

Equipment plus properly trained people, and a lot of other things—of which IMPACTS is one—equals combat capability. Tighter dollars and fewer people make vigorous employment of IMPACTS absolutely essential. IMPACTS is the viable, fully integrated and standardized MPTS program the Air Force needs.

Notes

[1]Binkin, Martin. *Military Technology and Defense Manpower* (Washington DC: The Brookings Institute, 1986), p. 102.

[2]U.S. Department of Commerce Bureau of the Census, 1984, and Statistical Abstract of the U.S., 1987.

[3]"C-17 Airlift Transport Training Development Plan," by C-17 System Program Office, Aeronautical Systems Division, Wright-Patterson AFB OH, May 1988.

[4]Maj Gen Smith, Monroe T., Deputy Chief of Staff, Product Assurance and Acquisition Logistics, HQ AFSC. "Keynote Address at the AFHRL MPT Conference," Brooks AFB TX, 11-13 May 1987.

[5]Binkin, p. 55.

Rivet Workforce and the F-16 Block 40: The Convergence of Training Issues in the 388 TFW'S Conversion

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Background

The 388 Tactical Fighter Wing (TFW) at Hill AFB, Utah, is undergoing a weapon system conversion from the F-16A/B to the C/D model aircraft. This represents the initial operational capability of the Block 40 version, incorporating an advanced avionics package that includes the Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) system, the Global Positioning System, and the Automatic Terrain Following system. As with any new capability, cadre training of unit level maintenance technicians is required. Further complicating the 388 TFW's conversion is the concurrent implementation of the Air Force's "Rivet Workforce" program designed to orient technicians to weapon systems and combine similar technology maintenance Air Force specialty codes (AFSCs).

With the onset of Rivet Workforce, Hill AFB faces a unique convergence of training issues during an already complex task of weapon system conversion. By nature, this requires additional planning and innovative management techniques by 388 TFW personnel to minimize the potential problems and the loss of operational training sorties. This paper examines the complications faced by the maintenance team at Hill AFB, in light of these training issues, and their approach to identifying and managing them. Although the Block 40 and LANTIRN capability will be fielded at only a few locations, many lessons learned by maintenance managers at Hill AFB are relevant to other units facing weapon system conversions.

Competing Training Issues

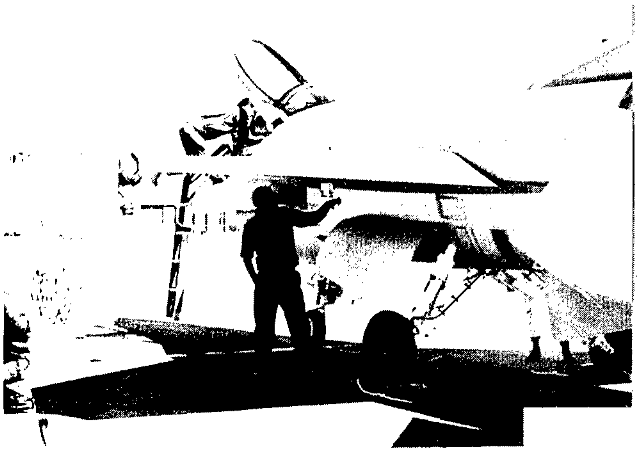
The concept of Rivet Workforce is aimed at doing more with less.

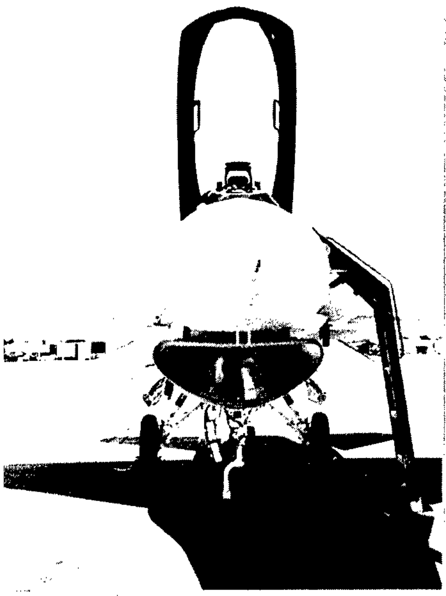
Rivet Workforce restructures the job categories into which maintenance technicians are grouped. Specifically, the objectives of Rivet Workforce are to develop technical expertise on a particular weapon system, combine jobs with similar underlying technologies, tailor training policies for enlisted force development, and restructure unit manning to allow reductions in total manpower levels. (2:4) Simply put, the concept of Rivet Workforce is aimed at doing more with less. As a result of combining AFSCs, the Air Force seeks to increase productivity; improve combat capability; and, at the same time, reduce overall manpower requirements.

The Air Force Rivet Workforce program staggers the conversion of maintenance AFSCs with a transition period of approximately three years for each AFSC. Of particular interest in the Hill AFB conversion is the transition of avionics technicians to the Integrated Avionics career field (AFSC 452X2), the first AFSC to undergo the transition in the Tactical Air Command (TAC). Integrated Avionics, responsible for flight-line repair of the complex F-16C/D Block 40 avionics, combines three previously separate functional areas: 326X6, "A Shop," which repairs attack control systems including radar and inertial navigation systems; 326X7, "B Shop," responsible for avionics instruments and flight controls; and 326X8, "C Shop," which fixes communications, navigation, and penetration aids like radios and electronic countermeasures. (13)

Under the Rivet Workforce concept, avionics technicians in the F-16 specific 452X2 AFSC remain identified with an A, B, or C "Shop" AFSC shred through the 5 skill level. At the 7 skill level, the 45272 technician must be qualified on all three avionics functional groups (13) and the AFSC shred is removed. Delaying full Rivet Workforce qualification ensures a certain career commitment and, thus, effective employment of the training involved. The crux of the transition is attendance at an F-16 crossover school held at a local field training detachment (FTD) or the Lowry Technical Training Center in Colorado. (4:25) These technicians are also required to complete the appropriate career development course and receive hands-on proficiency training.

The transition of the Integrated Avionics career field officially began in April 1987 and is expected to be completed in 1990, although TAC remains flexible in achieving this goal. Recognizing each base has unique requirements, TAC gives responsibility for the training flow of the people within Rivet Workforce to the "supervisor." (5:3) In other words, those best able to determine training availability and needs must identify and program the personnel for attendance at various courses. Within the 388th Aircraft Generation Squadron (AGS), as well as the other maintenance squadrons, maintenance supervisors and their staff maintain overall control of day-to-day training.



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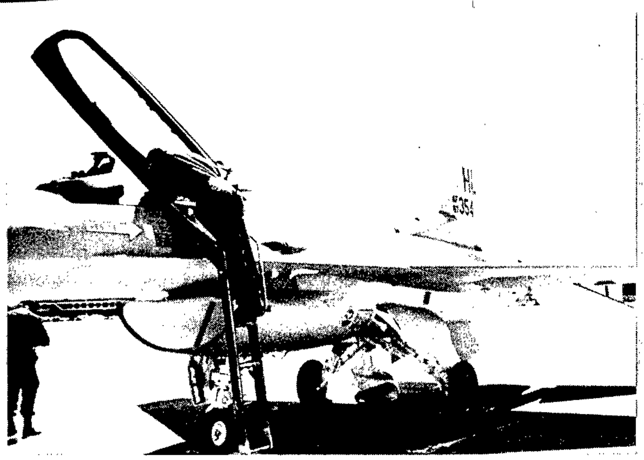

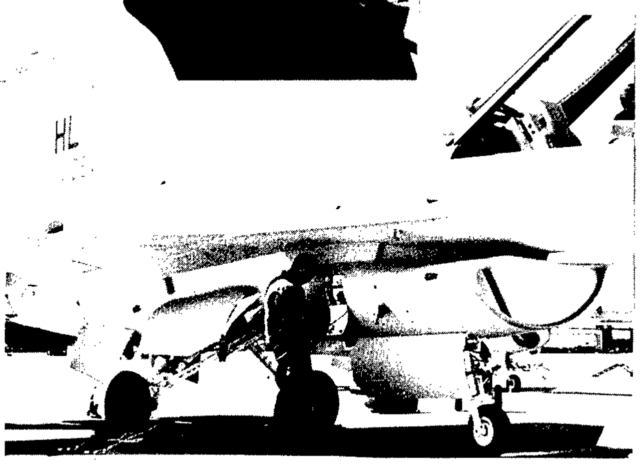

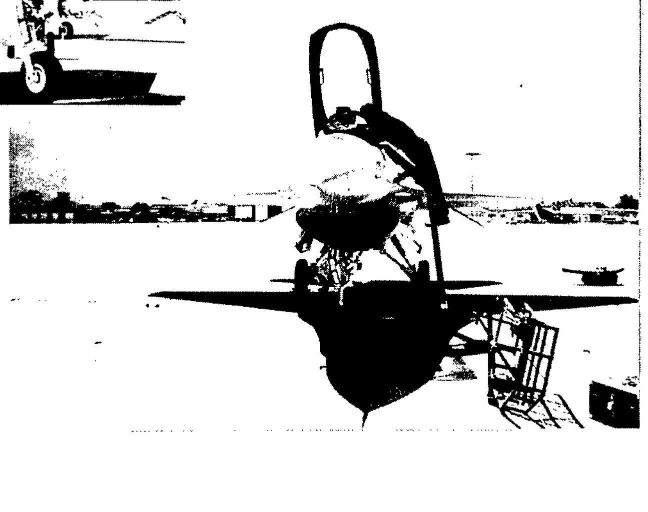

As Hill AFB, along with the rest of TAC, undergoes this Rivet Workforce transition, it simultaneously must manage the cadre training requirements for the F-16C/D Block 40 avionics systems. The Block 40 avionics is significant because it introduces entirely new systems to the operational Air Force, particularly the LANTIRN and related avionics systems. More so than other aircraft, the F-16C/D Block 40 avionics package is highly integrated and interdependent. In general, it provides an entirely new capability to the pilots and a new technical repair requirement for the maintenance community.

Block 40 cadre training for eight Hill AFB 452X2 technicians was conducted at the General Dynamics plant, Fort Worth, Texas, January through May 1989. Of the eight who received this "type 1" training, one was projected to leave the 388 TFW and become a local FTD instructor, which removes him from sortie production, but facilitates the training of other 388 TFW avionics personnel. (1) In addition, the 388 AGS plans to rotate the remaining seven from one aircraft maintenance unit (AMU) to the next as the conversion progresses, thus sharing their expertise and lessons learned across the squadron. (3)

Complicating the training of the cadre, as well as the technicians attending the FTD, "type 4" training conducted on site at Hill AFB, are the prerequisites for either type of Block 40 course. First, technicians should complete all mandatory Rivet Workforce FTD courses. Second, they must complete the F-16C/D difference course, upgrading their current A/B model qualifications. In all, training of cadre personnel entailed an absence from the flight line of some 17 weeks per person. It is anticipated that those specialists going through the type 4 local training will be away from sortie production duties for approximately 11 to 12 weeks. (9)

With the TAC-wide implementation of Rivet Workforce overlapping the initial fielding of the F-16 Block 40, the 388 TFW faces an unusual convergence of training issues. To summarize, they must train avionics personnel on the Block 40 systems; and, at the same time, they must train these technicians in conjunction with Rivet Workforce's combination of career fields. Not only must the 388 TFW manage attendance at the Rivet Workforce crossover courses, but also at C/D difference training and a Block 40 avionics course. These requirements are in addition to normal upgrade and A/B model training which remains necessary until the conversion nears completion.

The 388 TFW potentially faces a period of critical manning during the conversion if personnel are not properly managed. Increased manning seems justified, not only to compensate for the learning curve and slower repair times on the new avionics systems, but also to provide on-equipment, on-the-job training to other technicians and to fill in for those attending FTD or in-house maintenance training division classes. In theory, there are fewer available and qualified technicians, though logic implies that more specialists are needed to fulfill mission requirements. The Air Force solution is to augment the maintenance complex with 18 civilian contractors who can also assist with training during the conversion. In other words, these people serve as the wing's resident experts on the Block 40. (3)

What potential impact, then, do these training issues have on the 388 TFW's conversion process? If not adequately addressed, the loss of productive operational training missions could be significant. Further, if unit training is not conducted in a proper or timely manner, expertise on the weapon system could be deficient. Finally, if the 388 TFW fails to manage the Rivet Workforce program, it could fall significantly behind the timed phase-in for Rivet Workforce, though the influx of trained personnel from other F-16 units could offset this shortfall. Ultimately, training delays could place the wing in a position where assigned personnel cannot meet sortie requirements, especially since Headquarters TAC has determined that Rivet Workforce and improved aircraft reliability and maintainability have reduced F-16 manpower requirements across the Air Force. These adjustments will be made sometime in the future, when the Rivet Workforce program is well implemented. (8)

388 TFW's Management Process

Planning to fulfill these training requirements during the conversion process began at the major command level and filtered down to the wing. Long before the actual aircraft conversion began, that is, before the first A/B model F-16 left the base or the first C/D arrived, a long-range planning process was underway. At the heart of the planning process is the Site Activation Task Force, composed of individuals from a broad spectrum of Air Force activities, each playing a central role in the conversion's success. Managers from TAC, Air Force Logistics Command, Air Force Systems Command, Air Training Command, General Dynamics, and the 388 TFW conducted meetings to address issues early on in the conversion process. The first of three meetings was held in February 1988 and the last one in April 1989. These meetings provided face-to-face contact with key players from diverse locations and produced specific "actions items" which were tracked and, for the most part, resolved prior to the third meeting. (10,11,12)

At the 388 TFW, the maintenance complex established a Maintenance Conversion Project Office at the Deputy Commander for Maintenance (DCM) staff level. This office is the focal point for managing all maintenance-related conversion items and keeps the DCM current on the status of the conversion. Under this umbrella office, each squadron or division maintains a conversion office to manage items peculiar to its functional area. (15:B-1) These offices met on an ad hoc basis, with the exception of attendance at the site activation task force meetings, until the DCM recognized the need for improved communication within the maintenance complex and initiated biweekly meetings.

Has the management of these training issues been adequate within this framework? In the 388 TFW, the answer is a qualified "yes." In terms of the 452X2, Integrated Avionics AFSC, 85% are projected to be Rivet Workforce qualified by July 1989 (14), which completes this prerequisite for attending Block 40, type 4 training. In addition, the maintenance complex has devised and followed training management plans to ensure both Rivet Workforce and F-16C/D Block 40 training is received in a timely manner. In fact, the DCM front-loaded training requirements, intentionally accelerating the Rivet Workforce training for avionics technicians, in order to provide a certain flexibility once the aircraft conversion was in progress. (7) In other words, as production requirements increase with the

transfer of aircraft, training requirements should decrease to a degree, thus improving personnel availability.

On the other hand, there are also training-related issues that could be problematic in the absence of ongoing attention. First, the flying commitment has remained virtually unchanged during the months immediately preceding the start of the conversion—a period of increased training for the maintenance community based upon the DCM's decision to front-load training. The wing did not significantly decrease its deployments or substantially ease its sortie rate. (1) Plus, as the reigning champion, the 388 TFW is preparing to defend its title in the Gunsmoke 1989 competition, which further depletes the work force dedicated to day-to-day operations.

Although it is true that deployments can increase aircraft use by removing other concerns and commitments, allowing them to produce more sorties with fewer aircraft, the home station can be left shorthanded. This is especially likely in those specialties in which people are also attending training courses for Rivet Workforce and Block 40 upgrade. As a result, AGS supervision is employing its specialists on a squadron-wide basis, as opposed to them remaining strictly dedicated to one AMU under the AFR 66-5, *Communications Security (COMSEC) Equipment Maintenance and Training*, maintenance organization concept. (3) Clearly, with the existing flying commitments, the maintenance complex is using its personnel to the maximum extent with little or no slack.

Another potential shortfall in their management of training is the Rivet Workforce implementation for AFSCs other than Integrated Avionics. According to the AGS Commander, the conversion is their priority; and each AMU will delay some of the Rivet Workforce training until it has converted. This translates into a few months' delay of the program. Of concern are trained engine specialists. Although they can be cross trained into other Rivet Workforce duties fairly rapidly, it is much more difficult to train the crew chiefs on engine tasks. Similar problems exist with the combination of environmental systems specialists and electricians. (3) Eventually, this delay in Rivet Workforce implementation could have an adverse impact on unit manning since the Air Force is projecting personnel reductions. (8)

Finally, the greatest obstacle to the successful management of training issues during the conversion is the newness of the weapon system itself, and this shortcoming is driven at levels above the wing. Although common to an initial operational capability of any weapon system, two major problems in successfully training the work force at Hill AFB are the absence of technical data and the lack of C/D model aircraft for training purposes.

The technical data simply have not been available from the contractor since Block 40 systems and the technology are still under development. Civilian contractors have been assigned to the 388 TFW to help fill in the gap left by this absence of written documentation. In addition, to prevent training delays, permission has been granted for FTD classes to use "manuscripts" until they receive finalized technical orders. However, in some cases, even these manuscripts are being delivered late-to-need. (12)

Hill AFB received loaner C model aircraft from Luke AFB, Arizona, and MacDill AFB, Florida, to support its C/D difference training. (12) This permitted accomplishment of one significant step toward conversion, but with the newness of the Block 40 and the introduction of some fundamentally new systems, training remains incomplete until the Block 40 version is available. The arrival of the first Block 40 F-16 at Hill AFB on 17 May 1989 allowed this training to begin. (6)

Even so, the training on the new aircraft is limited initially and will remain so until more aircraft arrive. This may be problematic for the cadre avionics technicians who received type 1 training from the contractor. (NOTE: One of the main purposes of cadre personnel is to train other unit technicians on the new equipment. If they are not used for this purpose, cadre training will certainly be underutilized.) Since they are considered trained and qualified on the Block 40, their access to the aircraft is of a lower priority than access for the technicians undergoing the upgrade. As a result of not applying their knowledge on a regular basis, the cadre's expertise is declining to a degree. The longer the period between their training and the arrival of the main contingent of Block 40 aircraft, the more this cadre training loses some of its impact.

Although this problem can be minimized at the wing level through the manner in which the cadre is employed, the issue ultimately lies with Headquarters TAC and USAF, who make the decision on when and where to field a new weapon system. The question is raised: Should the Air Force field a new weapon system at an operational unit before it has been fielded at a training wing? Even delaying operational fielding would not completely eliminate the training problems for units converting subsequent to the training wing.

A second question is whether the managers of various programs at the headquarters level work in a coordinated manner such that the issue of Rivet Workforce implementation overlapping the wing's conversion was examined far in advance. If not, how can the major command better manage its various programs to identify similar situations in the future and, perhaps, develop contingency plans or agree to concessions on a case-by-case basis? This could improve the likelihood of successfully completing both taskings and prevent degrading one program at the expense of the other. (NOTE: The issues described in this paragraph should be addressed during SATAF, conducted by the MAJCOM.)

Lessons Learned

Some lessons can be learned from this examination of the 388 TFW's conversion at the front end of the process; and, likewise, some questions must remain without answers until its conclusion in 1990. First, the unit level managers must successfully react to issues initiated or created by organizations above them. They cannot control the decision or the timing to field the F-16C/D Block 40 at the 388 TFW. They cannot control the availability of technical data or aircraft on which to train, or the manpower pool available to the wing. However, wing level managers can identify critical issues; and, if done so early enough, they can significantly reduce their impact. A successful conversion is not possible without managers who possess foresight, react to existing and potential conditions, and force resolution.

This means that the unit must also be proactive; managers, themselves, must be agents of change. A good example is the DCMs' decision to front-load training requirements for some of their personnel. This gives them a margin of flexibility that may prove to be a key element in maintaining combat capability and producing the required sorties in the months ahead. In addition, the wing has prioritized training requirements and made the C/D and Block 40 training take precedence over the Rivet Workforce transition, if necessary. Again, this proactive planning should help smooth the turbulence of conversion.

The experience of the personnel involved in the conversion is the third element contributing to the likelihood of success. At the 388 TFW, many of the maintenance managers have previous experience with weapon system conversions. This knowledge base, when combined with the assignment to the wing of technicians who have previously worked on the same model aircraft, should prove helpful. In fact, future conversions will benefit from the Rivet Workforce program, since technicians now remain with a specific aircraft throughout the greater part of their careers. As a result, training requirements are reduced considerably and lessons learned from other units are shared as first-hand experiences.

Lastly, two important issues surface. First, the maintenance complex is clearly using its personnel to the maximum extent possible given the multitude of training needs and flying commitments. Must the wing maintain this level throughout the conversion or will their planning and early training provide them with the flexibility to return to normal levels of personnel use? If they cannot return to normal levels, will maintenance be forced to reduce some requirements not critical to the conversion?

The second major issue extends beyond the conclusion of the conversion: Will the delay in completing the training for Rivet Workforce AFSCs ultimately have any measurable impact upon the 388 TFW maintenance complex's ability to support the flying mission, even with the projected influx of personnel from other bases? How complete will the Block 40 training and qualifications be after the conversion is done, if the Rivet Workforce training was not fulfilled in some cases as a prerequisite? Clearly, the training challenges extend well beyond the conversion's culmination in 1990.

In conclusion, the F-16 conversion in the 388 TFW at Hill AFB involves unusual and complicated training issues based upon managing not only training for a new weapon system, but also for new Rivet Workforce AFSCs. Overall, early planning, combined with innovative management techniques and previous experience with other conversions, has made for a smooth start to the wing's conversion. The critical training issues still require careful, ongoing attention at all levels in the 388 TFW's maintenance complex to ensure the conversion proceeds without impairing the wing's combat capability or the production of adequate levels of training sorties.

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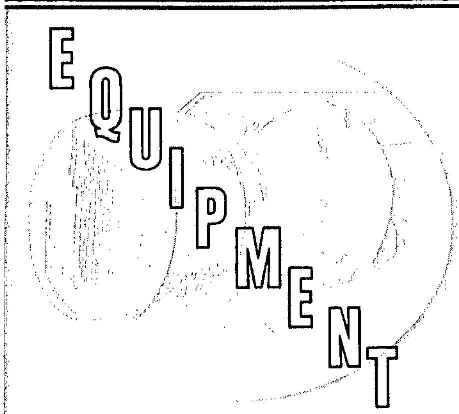
Most Significant Article Award

The Editorial Advisory Board has selected "Bashing the Technology Insertion Barriers" by Stephen J. Guilfoos as the most significant article in the Spring 1989 issue of the *Air Force Journal of Logistics*.



The next two articles touch on the subject of bad actor management. MSgt Richard Abernathy's article, "Fix It Before It Breaks," presents an excellent summary of the policy recommendations from the AFLMC's "Bad Actor Management Study" along with other important avionics maintenance issues. Additionally, Jean Gebman and Major Jeff Snyder present an outstanding case for tracking bad actors by serial numbers in their article, "Serial Number Tracking of Avionics Equipment." As an introduction to these articles, it would be useful to review what are "bad actors."

What Are Bad Actors?

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(Author of "The Bad Actor Management Study")

Bad actors are line replaceable units (LRUs) or shop replaceable units (SRUs) that repetitively enter the repair cycle at a rate significantly greater than units with the same part number. In plain terms, "they're lemons." One of the keys to dealing with these poor performing individual LRUs and SRUs is understanding what causes them so appropriate steps can be taken to repair or eliminate them. As part of the "Bad Actor Management Study," the project team at the AFLMC consulted with reliability experts within the Air Force, academe, and private industry to categorize the causes of bad actors based on reliability theory and practical experience. We arrived at four categories: intermittent failures, differing subpopulations, vertical testability problems, and test voids. I describe each below to help logisticians dealing with bad actor management understand the multifaceted nature of the bad actor problem.

Intermittent Failures

Intermittent failures are a familiar and frustrating cause for LRUs/SRUs to enter the repair cycle repeatedly. A failure that occurs randomly can easily frustrate a technician's attempts to isolate the problem. Similarly, a failure that happens only under certain operational conditions—for example, only at negative three Gs—can make the problem difficult to duplicate and properly troubleshoot. In both examples, the LRU/SRU may retest OK on the test bench only to fail again in operational use just a short time later. Even when maintenance is performed, technicians may not know whether they found and corrected the right problem until the unit comes back to the shop for further repair.

Subpopulations

Another common—but less understood—factor leading to individual bad actors is the problem of subpopulations within the overall inventory of an item having differing reliabilities.

All else being equal, the entire inventory of identical LRUs/SRUs should tend to display mean times between failure (MTBFs) that cluster around the population average. As an example, Figure 1 shows the MTBFs for two groups of LRUs. The first group is made up of 990 LRUs and has a population MTBF that clusters around 500 hours. Random chance will cause some variation from the average MTBF and this is shown by the spread towards the tails of the distribution. Within this group of LRUs, we would not find any bad actors due to subpopulations because statistically all the LRUs have the same MTBF.

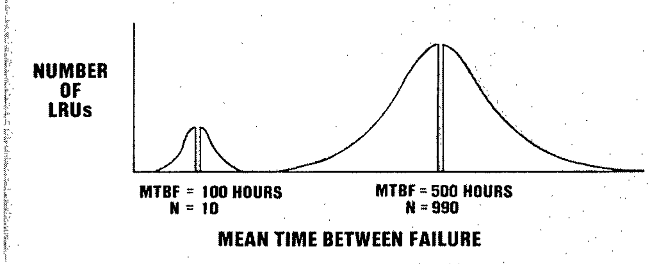


Figure 1: Subpopulations.

However, if a small number of the LRUs/SRUs come from a subpopulation different than the bulk of the units, then a second distribution (shown by the small hump in Figure 1) may appear. In this example, the bulk of the LRUs/SRUs have an average MTBF of 500 hours. However, a small number of LRUs/SRUs have MTBFs that cluster around 100 hours. When these LRUs/SRUs—with the lower MTBFs—are distributed in small numbers throughout the Air Force inventory, they tend to pop up as bad actors because they will enter the repair cycle much more frequently than their more reliable counterparts. Several reasons exist for such subpopulations:

Different Lots/Vendors

If a vendor provides the Air Force with a small lot of low reliability LRUs/SRUs (when compared to the reliability of other lots), then a small subpopulation like the one shown in Figure 1 may be created. Similarly, if the Air Force uses more than one vendor for an item and one of the vendors provides a small number of low reliability LRUs/SRUs, then a subpopulation may also be created. In either case, the LRUs/SRUs in the low reliability subpopulation will tend to surface as bad actors when compared to the total population.

Environmental Stress

Environmental stresses can also cause subpopulation problems. Environmental stresses may—over time—induce changes in the reliability profiles of groups of LRUs/SRUs. For example, severe weather conditions (such as corrosion in coastal areas) may reduce the MTBF of components used at a coastal base. If an LRU/SRU—so affected—is shipped to an arid climate, it may show up as a bad actor because the bulk of LRUs/SRUs at the arid base may still be displaying the original higher MTBF. The same phenomenon can also be caused by differing mission profiles or handling in supply, transportation, or maintenance.

Age

The relative age of LRUs/SRUs can also cause differing subpopulations. The failure rate of electronic equipment tends to change as the equipment ages. Initially, the failure rate is high but decreases as manufacturing defects are detected and eliminated. This is shown as the infant mortality phase on Figure 2 and is also known as the burn-in period. Following burn-in, the equipment enters its useful life where the failure rate is constant. When the equipment nears the end of its useful life, failures again begin to increase in frequency. The equipment is then in the wear-out phase. This pattern is often called the "bathtub curve."

The arrows in Figure 2 show how a subpopulation problem may arise if the bulk of LRUs/SRUs in an inventory are in the constant failure rate or useful life phase, but a small subpopulation is somewhere in the infant mortality or wear-out phases. When this happens, members of the high failure rate subpopulation may show up as bad actors.

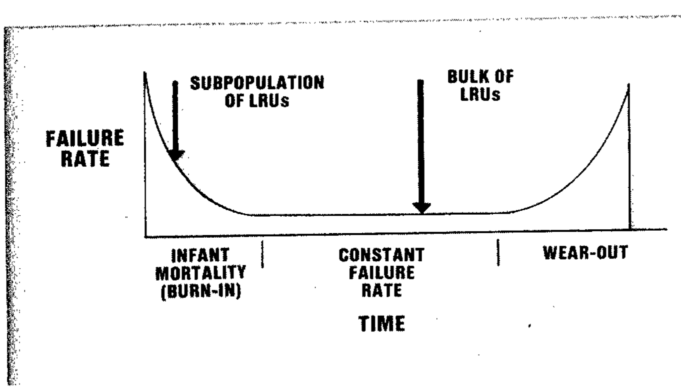


Figure 2: Reliability Bathtub Curve.

Vertical Testability

Like intermittent failures and differing subpopulations, vertical testability problems can cause bad actors. Vertical testability addresses the ability of each level of maintenance—organizational, intermediate, and depot—to detect the same set of failures on an LRU/SRU. Ideally, the tolerances of test equipment and procedures for troubleshooting a problem at all three levels should be the same or should become more stringent as a unit goes to the next higher level of maintenance. Thus, if the built-in test on an aircraft detects a fault, the avionics intermediate shop (AIS) can duplicate and isolate the failure. Similarly, problems detected with the AIS can be replicated at the depot. Unfortunately, this may not always be the case.

Sometimes the tolerances on the aircraft are tighter than on the AIS, or the AIS is more sensitive than depot test equipment. Problems occur when a failure is just outside the tolerances at one level of maintenance but within standards at the next level. An example will help illustrate the problem.

Figure 3 shows a failure that lays just outside a standard of plus or minus 1 on an aircraft's build-in-test. However, the failure is within the tolerances at both the intermediate and depot levels which are plus or minus 3 and 5 respectively. The LRU/SRU will fail the built-in-test on the aircraft but pass the test on the AIS. After several repeats, the unit may be sent to the depot where—in this example—it will again pass the depot test station tests. Assuming nothing else is done, the unit will be issued to a new base where the cycle of failure followed by "retest OK" will repeat.

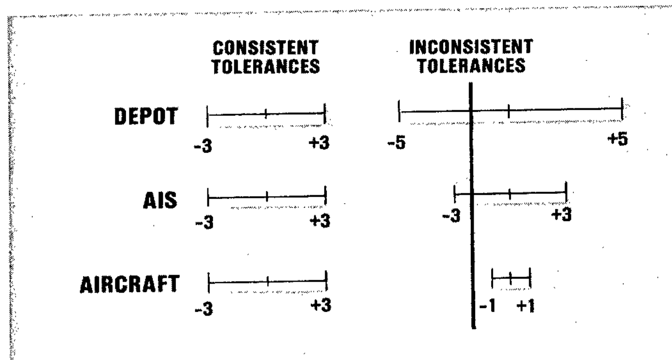
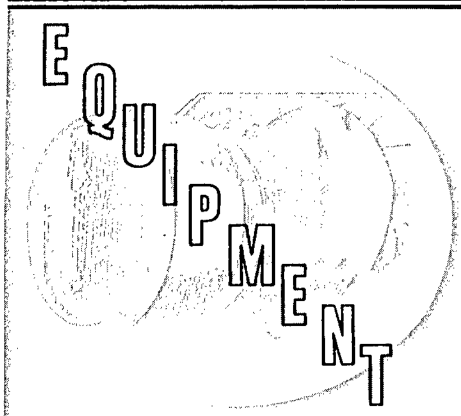


Figure 3: Vertical Testability Problems.

Test Voids

The last cause for bad actors is test voids. Test voids are similar to vertical testability problems because they address the ability of maintenance procedures and techniques to detect faults in an LRU/SRU. A test void exists when an LRU/SRU experiences a failure in operational use, but the established troubleshooting procedure or test station software is not designed to detect that particular fault. The problem may be a complete test void where the test station is simply not designed to detect a particular failure mode. Alternatively, the problem may be a dynamic test void where units are tested alone on the station, but the problem is only manifested when the unit is operating in conjunction with other units installed onboard the weapon system.



Fix It Before It Breaks

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Introduction

For several years Tactical Air Command (TAC) units have been experimenting with some promising preventive maintenance initiatives. These unit level programs have recently received command level support and advocacy. The Commanders of TAC and the Air Force Logistics Command (AFLC) agreed jointly to pursue a program to prevent untimely and unscheduled maintenance. This "Fix It Before It Breaks" program is a new preventive maintenance initiative geared towards avionics components. This article is an overall look at the program, its goals, and its initiatives.

Background

The program evolved from the belief that today's improved fault detection and fault isolation capabilities in our aircraft and line replaceable units (LRUs) are not being fully exploited. Traditionally, airplanes were only repaired when the aircrew documented a faulty system. LRU self-test and built-in diagnostics were virtually ignored, causing LRU performance to be invisible until a failure—or a pull from the supply system—occurred. To make matters worse, a significant amount of avionics maintenance effort was being wasted because 25% to 35% of pulled LRUs resulted in cannot duplicate/retest-okay (CND/RTOK) actions. Compounding that situation were "bad actors"—individual LRUs or shop replaceable units (SRUs) that enter the repair cycle at a rate significantly higher than LRUs or SRUs with the same stock number. These bad actors can increase intermediate level maintenance workload by as much as 30%.

Reduce the overall cost of maintenance.

It is the goal of the Fix It Before It Breaks (FIBIB) program to reduce the overall cost of maintenance through three basic initiatives:

(1) Maintaining key LRUs at improved levels of performance.
(2) Reducing unnecessary LRU removals.
(3) Removing "bad actors" from the maintenance system.

Maintaining Key LRUs at Improved Levels of Performance

We will identify at least three LRUs per aircraft type which have a poor performance record and measurable performance parameters. We must reexamine established performance standards, track and analyze LRU performance trends, and implement fixes. An improved LRU performance program has already proven to be highly successful with the F-16A/B Inertial Navigation Unit (INU). The 58 Tactical Training Wing (TTW) and the 388 Tactical Fighter Wing (TFW) developed and implemented INU performance improvement programs which have dramatically improved their reliability and weapon accuracy. This aggressive program, which is essentially a preventive maintenance program, is now the standard INU maintenance practice for TAC's F-16 fleet.

At the 58 TTW, the INU is checked during a preventive maintenance inspection scheduled in conjunction with weekly flying or when flagged by a performance tracking chart. This extensive tracking method has been developed to monitor parameter movement within the INU. The following information is manually logged on a tracking sheet for each aircraft tail number: Date; 128, radial error rate (RER); 134, navigational event; 135, navigational time; G.S., ground speed; and final latitude/longitude.

DATE	128	134	135	G.S.	FINAL LAT/LONG

This information is provided by the pilot during the postflight debriefing. The 128 data is monitored by the 58th in the following manner. The system is designed to operate at .8 RER and three flights are listed each time; i.e., greater, when any two flights are 1.8 or greater, or when all three are 1.2 or greater. The 58th's goal is for the RER to remain at less than 1.0 for each of the three flights. All information is monitored. When an INU indicates a movement towards an out-of-tolerance condition, an on-aircraft auto-calibration is performed to bring the INU back within the desired parameter. By performing the auto-calibration on the aircraft, technicians can save five to seven hours of avionics intermediate shop (AIS) time. The auto-calibration takes 85 minutes to perform on the aircraft, compared to six hours for an INU calibration and performance run on the AIS. Adding removal, reinstallation, and

transportation time, it can take more than eight hours to calibrate the INU in the shop. The 58 TTW averages 400 sorties between INU removals; they have had two INUs with more than 1,000 sorties before removal.

The preventive maintenance and INU data tracking methodology used by the 58 TTW and 388 TFW have proven invaluable and the results have been dramatic. The technicians are identifying problems, correcting them, and delivering a mission capable system in less time. The program reduces maintenance man-hours and increases mean time between failure (MTBF). Significantly, the 58th has increased F-16A/B INU reliability to twice the USAF average, while the 388th TFW's bombing accuracy contributed to their Gunsmoke 88 Bombing Competition victory. The essentials of their program have been incorporated into F-16 tech data and publicized in all Tactical Air Forces (TAF) aircraft maintenance organizations.

Reducing Unnecessary LRU Removals

Comprehensive, easy-to-follow fault isolation manuals are needed to isolate all possible discrepancies down to at least the LRU level. A significant portion of all LRU removals results in a CND/RTOK action at the intermediate shop level. The hardware and software available for use by the field maintainers are quite extensive. The F-16, for example, has the on-board technology to identify every fault from engine start through engine shutdown. Even though this information is obtainable, it is of little use when existing fault isolation manuals fail to address the problems experienced. This limitation defeats using the advanced hardware or software as a troubleshooting aid.

After the tech data guidance runs dry, maintenance personnel must resort to experience in determining which component is defective. However, experience alone is frequently inadequate in troubleshooting complex systems. This leads to incorrect LRU removals, increased maintenance man-hours, and decreased airframe availability and capability.

Many technical shortcomings could be eliminated if maintenance personnel would address fault manual deficiencies as they arise. This would allow incorporation of updated procedures into these manuals in a more timely manner. With the "Fix It Before It Breaks" program, we can readily identify deficiencies which cause these problems, change ineffective procedures, and provide a means to monitor the results. Perhaps we do indeed need to restructure some of our flight-line maintenance practices. A report by the RAND Corporation, "A Strategy for Reforming Avionics Acquisition and Support," states the F-16's fully mission capable (FMC) rate is above 80%, an impressive record by historical standards for this type of aircraft.[1] The FMC rate alone, however, is an incomplete measure since it only drops when crew members request maintenance and rises again as soon as maintenance is completed.

For avionics systems, flight-line maintenance can usually be completed quickly because most actions are restricted to removing and replacing an LRU, which is then sent to a repair facility. Removal and replacement of an LRU or a CND action clears a discrepancy, but does not correct the real fault nearly 50% of the time. Therefore, we are allowing the FMC rate to drive our maintenance actions and overload our AIS with false pulls. This was the case during the Coronet Warrior war readiness spares kit (WRSK) flyout exercises, where the intermediate level CND/bench check serviceable rates were 26% for Coronet Warrior I (F-15) and 32% for Coronet Warrior II (F-16).

Removing "Bad Actors" From the Maintenance System

In the last several years, concern has been rising throughout the Air Force about bad actor LRUs and shop replaceable units (SRUs). RAND has conducted several studies showing the negative impact that individual bad actor LRUs have on mission capability and have briefed the results of these studies at the highest levels within the Air Force. For example, one study at Bitburg AB, Germany, indicated that 9% of the F-15 radar LRUs consumed 41% of the repair shop visits but provided only 3% of the operating hours for the radar system.[2] Tactical Air Command determined that 7% of the LRUs used during the Coronet Warrior I consumed nearly 40% of the total maintenance man-hours expended during the exercise.

In addition to studies highlighting the negative impact of bad actors, many base and depot maintenance organizations have independently developed their own methods for identifying, tracking, and repairing or eliminating bad actors. The Air Force as a whole, however, does not yet have a coherent set of bad actor policies and procedures. As a result, these individual efforts are fragmented and do not provide coordinated management of problem components.

Consequently, the Directorate of Maintenance and Supply (HQ USAF/LEY) tasked the Air Force Logistics Management Center (AFLMC) to examine bad actor management throughout the Air Force. In the final report from the "Bad Actor Management Study,"[3] the AFLMC established that there are six essential elements of successful bad actor management: (1) establishment of bad actor criteria, (2) availability of failure/repair data at the serial number level, (3) marking and routing procedures, (4) special troubleshooting and repair procedures, (5) follow-up on repairs, and (6) policy guidance. Since, bad actors are a major emphasis within the "Fix It Before It Breaks" program, the conclusions of the Bad Actor Management Study warrant further elaboration.

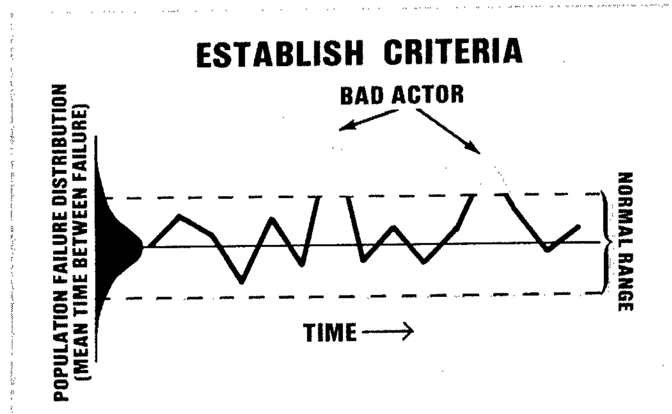


Figure 1: Bad Actor criteria should be based on how far the failure pattern for an individual LRU deviates from the average performance for like LRUs.

Establishment of Bad Actor Criteria

Only the F-15 and F-16 bad actor test programs have published criteria on what qualifies a unit as a bad actor. In other programs (where there is no agreed-upon criteria), there is often disagreement between the base and depot level over what qualifies for special treatment as a bad actor. Further, identification is difficult because it is not clear what should be tracked. A single Air Force-wide criterion to apply to all LRUs/SRUs would not be appropriate because of differences between weapon systems and mission profiles.

What's needed, therefore, is a method to establish different criteria for different systems as necessary. Ideally, the criteria would be based on actual LRU operating time until failure, not simply flying hours or calendar time (Figure 1). Flying hours or calendar time may be used, however, as a surrogate measure in those cases where elapsed time indicators (ETIs) are not installed on the LRUs or where there is a high correlation between actual operating time and one of these other measures. A simple, but effective, tracking method monitors the number of trips between the flight line and the intermediate repair shop for an LRU. If an LRU is bench checked serviceable three times within a given time period, a correlation check of flight-line aircraft discrepancies is accomplished and then a bad actor determination is made.

Availability of Failure/Repair Data at the Serial Number Level

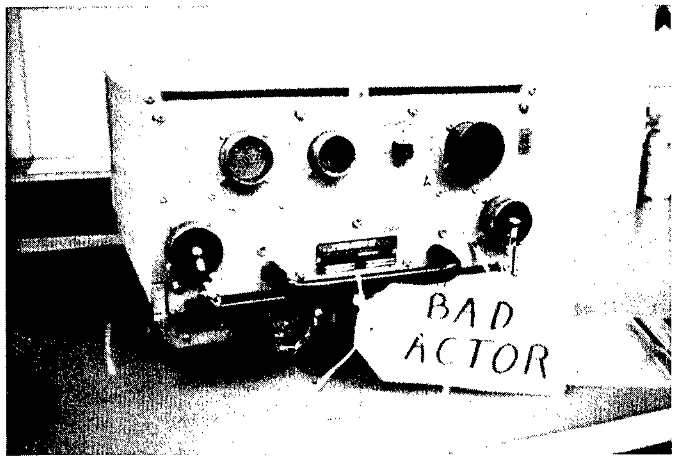
Data Collection at the Base Level. Serial number tracking of the performance of individual LRUs/SRUs is the key to bad actor identification. The availability at base level of a complete history of the failures and repair on a particular piece of equipment, however, varies dramatically across weapon systems. The most extensive data is available for F-16 units using the F-16 Central Data System (CDS) and the least for those units still using manual maintenance data collection. Units with the Core Automated Maintenance System have all the data elements needed to do bad actor tracking in their data bases, but a standard retrieval is not available to compare LRUs on station with an established bad actor criteria. Also, historical data on the past performance of a piece of equipment arriving on base is not available. If the central data base in the Reliability and Maintainability Information System (REMIS) is established as planned, it should eventually fill this gap.

In all cases, the system manager and using commands must first make the primary decision of determining which components warrant serial number tracking for the purpose of bad actor tracking, and then mandate collection of that data.

Data Collection at the Depot Level. The F-16 depot possesses extensive data on LRU/SRU performance using the F-16 CDS. Other depots, however, must rely on manual logs or microcomputer programs they have developed themselves. The Depot Maintenance Management Information System (DMMIS) will reportedly be capable of fully tracking LRU and SRU histories during depot maintenance. Current plans, however, are to use this capability only on a restricted number of items and then only for limited periods of time.

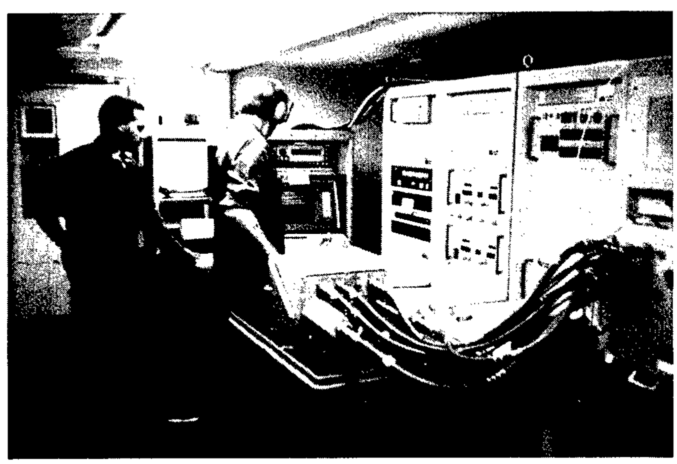
Marking and Routing Procedures

Currently, all the procedures for identifying a bad actor at the depot are ad hoc and not addressed in published directives. As a result, special identifying marks or tags are often removed in the supply and transportation systems.



Base-level maintenance shops have tried a wide variety of tagging techniques to mark Bad Actor LRUs, but none are part of the "official" system.

Standard procedures need to be established for marking bad actors and routing them through the maintenance, supply, and transportation system. At a meeting in March 1989, TAF, AFLC, and aircraft system program managers agreed upon general procedures. Specific direction is being worked through a coordinated effort between TAC and AFLC. These directions may use a variation of either TO 00-35D-54, Deficiency Reporting, or "Lead the Fleet" procedures as outlined in AFM 67-1, *USAF Standard Base Supply Procedures,* Volume II, Part 2, Section V, Chapter 21. In any case, procedures will dictate special handling, tracking, and disposition.



Avionics technicians with the 187th TFG (ANG) try to isolate the problem with a Bad Actor LRU.

Special Troubleshooting and Repair Procedures

Troubleshooting and repairing a bad actor is the most important and most difficult element of bad actor management. If normal troubleshooting and repair procedures were effective, most units would never become bad actors in the first place. Therefore, once an item is identified as a bad actor, it must be removed from the normal maintenance cycle and extraordinary

efforts applied to it. Selection of the proper technique depends mainly on the suspected reason for the item's failure.

The base level maintenance shops are constrained by available equipment and technical order requirements from extraordinary troubleshooting or unauthorized repair. To equip and man every base level facility to handle the engineering tasks necessary to solve bad actor problems is not feasible. Thus, the ultimate responsibility for bad actor troubleshooting and repair must fall on the supporting depot. Depot repair facilities, however, may not have the engineering expertise, equipment, or authority to go beyond established technical order procedures.

To meet the challenge of troubleshooting and repairing bad actor LRUs/SRUs, the depots have three options available. The relative merits of each alternative change from weapon system to weapon system depending on the nature of the equipment and the capabilities of the depot shops.

(1) *Augment the depot facilities with engineering support, equipment, and authority to apply extraordinary troubleshooting and repair procedures to bad actor LRUs/SRUs.* This would make the depot Director of Maintenance (MA) primarily responsible for bad actor management. Bad actors could be forwarded to the depot using an existing, or new, not-repairable-this-station (NRTS) code. This alternative is best suited to older weapon systems that do not use I-level/D-level automated test equipment and whose bad actors are caused primarily by intermittent failures and subpopulation problems.

(2) *Treat all bad actors as materiel or software deficiency report exhibits and make the item/system managers responsible for applying the engineering expertise/facilities necessary to troubleshoot the problem.* This alternative is most appropriate for newer weapon systems that rely heavily on automated test equipment. Here, vertical testability problems and test voids in the automated test equipment are the predominant causes for bad actors. The resources available to the depot Director of Materiel Management (MM) are best suited to handle bad actors in these circumstances.

(3) *Establish contract support for the troubleshooting and repair of identified bad actors.* This alternative may be appropriate in one of several situations: when the LRUs/SRUs are under warranty, for new weapon systems still in the final phases of operational test and evaluation, or when the necessary engineering expertise or equipment is not available at the depot to make either option "1" or "2" possible.

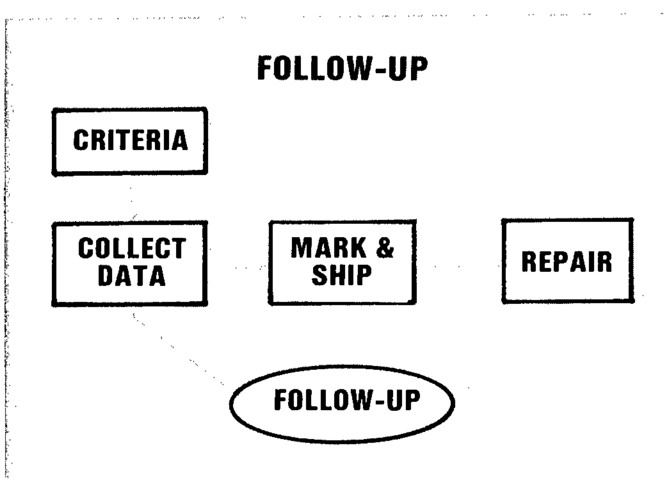


Figure 2: Follow-up on bad actors can be passive or active, but ultimately must verify that the "fix" worked.

Follow-Up On Repairs

Follow-up on corrective actions that are taken to correct bad actors is needed because unique procedures may be used to troubleshoot and repair bad actors, which consequently, may not always work.

Follow-up actions can be either passive or active (Figure 2). Passive follow-up would collect data on the performance of the repaired LRU/SRU like any other unit. If it does not trigger the established bad actor criteria again, it would be considered fixed. The advantage of this approach is that it requires no more monitoring than that used to identify bad actors in the first place. The disadvantage is that a unit may have to fail several times for exactly the same reason before poor performance is detected.

Active follow-up closely monitors the performance of the repaired LRU/SRU when it is placed back in service. This requires that the history of the LRU/SRU past performance be made available to the using base. If the unit returns to the same base, this data is likely available either in the base's AFTO Form 95, Historical Record File, the CAMS data base, or shop log books. If the unit is sent to another base, active follow-up requires that a complete history of the component be forwarded to that base and used when the item returns to the shop for repair.

Policy Guidance

The key to an effective bad actor program is clear guidance addressing each primary agency's responsibilities and the procedures they should follow. In discussions with base level maintenance personnel working with the F-16 bad actor program, the most common complaint was frustration with obscure bad actor procedures. They often conflict with other base agencies when the procedures are not supported in existing technical orders and regulations.

Two levels of guidance are needed to make an Air Force-wide bad actor program work. First, overall guidance needs to address the primary responsibilities of AFLC and the using commands by establishing specific bad actor procedures. This would be best handled as an Air Force-wide 66-xx series regulation. Second, specific procedures must be established to identify, track, label, ship, repair, and follow up bad actors. This should be established in the 00-20 and 00-35 series technical orders and also the maintenance and supply regulations.

Conclusion

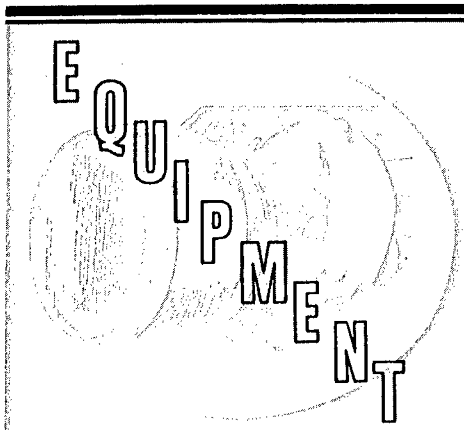
The opportunities exist to get smarter with the parts on hand and to reduce our workload. At the same time, using command/AFLC/AFSC teamwork will get us started and keep this program on track. We can continue to improve combat capability at reduced cost—being the best with less.

Notes

[1]Gebman, J. R., and Shulman, H. L. "A Strategy for Reforming Avionics Acquisition and Support," RAND Report Number R-2908/2-AF, July 1988, RAND Corporation, Santa Monica CA.

[2]Unpublished RAND report.

[3]Air Force Logistics Management Center. "Bad Actor Management Study," by Captain Getter, William, AFLMC Project LM870736, April 1989.



Serial Number Tracking of Avionics Equipment[1]

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Introduction

Tracking of Air Force aviation electronics (avionics) equipment by serial number has long been a contentious subject. The logistics community has not yet universally accepted this need. As some logisticians see it, the development community should solve the problem by improving designs. Maintenance personnel should not have to keep detailed historical records since their primary job is to be prepared to fix airplanes quickly. Although placing greater burdens on the developers may help future systems, it will not help currently fielded systems. For these systems, only tracking equipment by serial number can help identify specific items of avionics equipment that have hard-to-find faults which evade prompt correction and thereby undermine combat effectiveness while wasting maintenance resources.

Need for Serial Number Tracking

Serial number tracking is needed by pilots as well as maintenance technicians at all three levels of the maintenance process: on the flight line, in the air base avionics shop, and at the depot repair center.

To see and shoot the enemy first, the Air Force aims at superior functional performance, reliability, and ease of maintenance.

Pilot's Perspective

Combat aircraft like the F-15 contain very sophisticated avionics that enable them to meet a wide range of combat challenges. To see and shoot the enemy first, the Air Force aims at superior functional performance, reliability, and ease of maintenance. The last two goals have been especially difficult to achieve in its avionics suite. By exploiting advanced technologies to meet the increasingly capable threat, the Air Force has relied on increasingly complex equipment and increasingly complex integrations among this equipment. All of this capability must be operating at its full designed capability if combat pilots are to perform their mission with an acceptable chance of success or even survival. What the combat pilots need is confidence that the aircraft has been maintained in such a way as to ensure its full designed capability. If that full designed capability is not available on their aircraft, they need to be informed as to what degradation exists so they can vary their mission or tactics to compensate for that degradation. Such information can be provided only if performance degradations are tracked by individual aircraft. Such tracking of aircraft by their tail numbers is serial number tracking at the aircraft level.

Flight-Line Technician's Perspective

Supporting the full designed capability of mission essential avionics equipment has become increasingly more challenging in recent years. Today, avionics equipment rarely experiences total failure. Rather, it typically falls victim to faults that erode its performance superiority over potential enemy weapons. When equipment fails to deliver its full measure of designed performance, the performance degradation is often subtle and difficult to observe. In addition, faults may develop symptoms that occur only in specific operational modes. A subsystem with multiple modes, like a fire control radar, can have a fault that affects performance in only certain modes. Other faults may develop in specific environments, such as in an aircraft that may be vibrating or executing a violent maneuver. An item of equipment with this type of fault all too often circulates between the shop and the airplanes, degrading the full designed capability of combat aircraft, either until it acquires a more easily observable fault or until maintenance technicians set it aside for special attention. Such items are commonly referred to as *bad actors*.

The result of this intermittent observability of modern day avionics faults is that the flight-line technician faces a frustrating task in trying to identify and correct faults in the avionics systems of combat aircraft. Built-in-test (BIT) checks done on the ground frequently will not duplicate symptoms of faults that either the pilot or the BIT detected while airborne. To further complicate matters, pilots of combat aircraft tend to underreport symptoms of faults, even when they may materially degrade performance.

The extent of underreporting with fighter aircraft was documented during 1984 by a special Air Force project entitled "F-15/F-16 Radar Reliability and Maintainability Improvement

Program." This program included special six-month data collection efforts led by the Hughes Aircraft Company and the Westinghouse Defense and Electronic Systems Center. For flights where pilots or BIT detected symptoms of faulty operation of the radar, maintenance technicians were not told about the symptoms for 80% of the F-16 flights and 50% of the F-15 flights. The reasons offered for underreporting ranged from lack of confidence in the BIT systems on the aircraft to concerns about the increased workload that full reporting would create for maintenance. Nonetheless, such practices deprive technicians of information that could help identify faulty line replaceable units (LRUs).

Such circumstances leave technicians with few choices when they are confronted with faults with intermittent symptoms. The technicians can sign off the pilot reported discrepancy as could not duplicate (CND) and return the aircraft to operational status, or they can remove a number of LRUs that could have caused the type of problem the pilot reported. If the technicians attempt to determine the history of the aircraft over the last few sorties, they must manually track through historical aircraft records kept in a file in an office in the maintenance complex. With the constant pressure of sortie production ever present, the technicians will, in all likelihood, decide to CND the aircraft or remove a most likely LRU, or several LRUs, and send them all to the air base's avionics shop. What the flight-line technicians need to correct these difficult avionics malfunctions is complete information from the pilots on all symptoms of faults that they or the BIT detect and a capability to review the past performance of an aircraft and its LRUs quickly.

Shop Technician's Perspective

Technicians in the air base's avionics shop often face a very frustrating bench check serviceable (BCS) situation. BCS, the shop equivalent of the flight-line CND, means shop technicians were unable to detect symptoms of faults that were detected on the aircraft. Sometimes this result is appropriate because the flight-line technician removed several LRUs from an aircraft in an attempt to isolate a reported fault. In such cases, several of the units presumably would have no fault. On the other hand, however, an LRU received from the flight line may in fact be faulty even though the test equipment in the shop indicates the unit is serviceable. Such a result can arise from a void in the shop's test logic or from the lack of a stressful environment (temperature variations and dynamic flight loads). Such a unit will be returned to the flight line, eventually causing another reported discrepancy, and then be returned to the shop for repair. Then the vicious cycle continues.

Shop technicians currently track (by serial number) LRUs that enter the AIS from the flight line. However, the information collected only reflects the shop's maintenance history for the individual LRUs. In addition, this information usually is entered onto cards that are stored in the shop—not readily accessible to the flight line.[2] Moreover, information regarding the history of the LRUs while installed in the aircraft is not available to the shop technicians. What the shop technicians need is the ability to quickly review the complete history of avionics LRUs that enter the shop with the goal of improving the quality of their repair. This requires quick access to information about the performance of individual LRUs before they arrive at the shop and then after they are repaired and returned to the aircraft. Such a capability would enable the shop to better ensure that complete and efficient troubleshooting is performed on each unit that arrives at the shop. Additionally, such a capability would allow the shop to identify more quickly those LRUs that are cycling most frequently between the aircraft and the shop; give special attention to fixing such units; and, if necessary, send them to the depot where more extensive troubleshooting is possible.

Depot Technician's Perspective

When such an LRU arrives at the depot for repair, it is usually accompanied by a condition tag that contains an often cryptic description of the current failure mode of the LRU. No detailed history of the LRU is available to the technicians. Given this lack of history of the unit, the result on the depot repair line will, in all likelihood, closely parallel that of the shop—the technicians will be unable to duplicate the symptoms of the fault reported by the base. The unit will then be returned to the supply system and sent, possibly with an unresolved fault, to another unit. What the depot needs is an ability to quickly review the history of an LRU that has arrived at the repair line. This increased capability would allow the depot to quickly identify units sent to them with long histories of problems and then ensure that these units are subjected to more extensive troubleshooting and even special engineering analysis as needed.[3]

Basics of a Serial Number Tracking System

Effective tracking of equipment by serial number must begin with a full debriefing of the pilot. It then involves record keeping by maintenance personnel on the flight line, in the shop, and at the depot concerning the status of equipment taken from the aircraft, tested, and repaired.

Full Debriefing of Pilots

The full debriefing of pilots, to include symptoms of all faults, is the cornerstone of an effective serial number tracking system. Since combat aircraft pilots are rarely given the luxury of flying the same tail number aircraft consistently, which would allow them to observe a degradation of performance in a specific aircraft, it is important that each pilot report all BIT detected and pilot detected symptoms of faults. This includes symptoms detected during Code 1 flights[4] that do not, in the pilot's opinion, constitute discrepancies that warrant the attention of maintenance technicians. A report of such symptoms on an information-only basis can provide the avionics technicians with an audit trail that allows them to track the performance of a radar system over time.

The implementation of a fuller, more complete pilot debriefing could be enhanced by a computer driven system that would provide an interactive menu of questions concerning fault symptoms. Ideally, such an automated system could employ data transfer units to capture information from the built-in-test[5] and personal computers to record information interactively from the pilot.[6]

An Information System

The record keeping required of flight-line avionics technicians in a serial number tracking system is substantial. For the system to be an effective aid to the technicians, the movement of LRUs between aircraft must be closely monitored and accurately documented. The realities of sortie production and the frustration of an imperfect BIT system have led to the practice of swapping LRUs between aircraft to isolate avionics faults. This practice of "swaptronics," although at times effective, creates an increased burden on a serial number tracking system. Accounting for this movement is critical, however, to monitor the performance of specific LRUs effectively as they move from aircraft to aircraft.

The volume of information involved with a serial number tracking system for combat aircraft avionics creates the need for a computer based information system with large storage capacity and, more importantly, the capability for rapid retrieval of information. This precludes the tedious review of manual records that technicians on the flight line and in the shop are forced to endure if they want to review the history of an aircraft or LRU. Fortunately, a requirement to search for a failure trend for a specific LRU within a matter of minutes can be satisfied by using either the data base management capability of a modern personal computer or the capabilities of a mainframe hosted information system. The Air Force has developed and is implementing the mainframe hosted Core Automated Maintenance System (CAMS) that offers some ability to retrieve aircraft and LRU histories by serial number.

Prototype Serial Number Tracking Capability

A prototype capability named Performance Oriented Tracking of Equipment Repair (PORTER) has been developed with the philosophy that an effective prototype would have to be viewed as a maintenance aid rather than a data collection burden. To do this, the prototype aims at providing information needed to track down faults; fixing them; and, in doing so, documenting the deficiencies in the support process that allowed these faults to escape detection in the first place.

The PORTER Concept

The PORTER philosophy means that the perceived value of its services must exceed the perceived burden of using it. Thus, burden must be minimized by making it easy to use. Technicians must be comfortable with both data entry and data retrieval procedures. Moreover, data products must be displayed in ways that are tailored to support specific maintenance tasks. Furthermore, all suppliers of information should receive a directly beneficial product that logically depends on the information they supply (Table 1). For example, while pilots must spend slightly more time in maintenance debrief, they would receive a preflight advisory that will make them more aware of potential problems with the airplane and would enable them to make more effective maintenance requests.

Development

Development of a prototype with such attributes required the active involvement of a field unit and a computer-based information system that was amenable to rapid and frequent changes. The 36th Tactical Fighter Wing based at Bitburg Air Base, Federal Republic of Germany, volunteered to assist in both the development and demonstration of the prototype. Personal computers and a standard data base management package were selected to provide needed flexibility. Development and demonstration of the prototype were managed by the Strike System Program Office (SPO), Aeronautical Systems Division (ASD), Air Force Systems Command (AFSC). The principal contractor was the Support Systems Associates, Inc. (SSAI).

Figure 1 shows how maintenance information currently flows without a PORTER capability, and Figure 2 shows how it flows with the prototype PORTER capability.

Demonstration

Three radar LRUs were identified as bad actors by the Bitburg Air Base technicians and were sent to Warner Robins Air Logistics Center for extensive engineering testing.

PORTER'S PRODUCTS AND BENEFITS

Supplier of Information	Product Received	Benefit Perceived
Pilot	Preflight advisory	Situation awareness
	Postflight fault history	More effective maintenance requests
Debriefer	Fault history by subsystem	Fewer fault entries due to more timely maintenance requests
Flight-Line Maintenance	Composite history of faults, maintenance actions, and resident LRUs	Fewer LRU removals due to more rapid fault isolation
Shop Maintenance	Composite history of LRUs	Quicker case development for bad actor LRUs

Table 1.

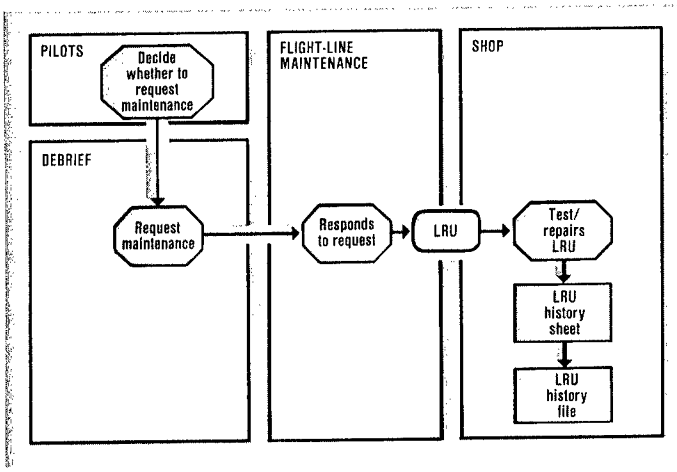

Figure 1: Current information flow without a PORTER capability.

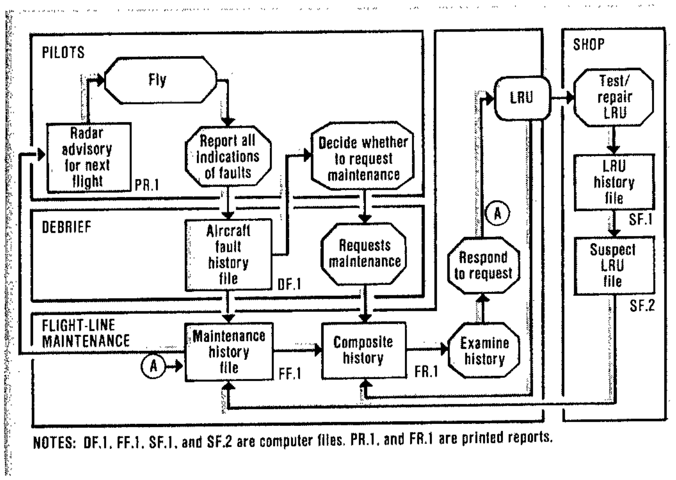

Figure 2: Maintenance information flow with the prototype PORTER capability.

The case history of one of these LRUs offers powerful evidence of what a PORTER-like capability can offer to the maintenance technician. The unit, a radar transmitter, had accumulated 52 hours (approximately 40 flights) in 1986 and had made nine visits to the shop during that period for failing the "blanking gate" BIT and the "RF No Go" BIT. The Bitburg technicians were unable to correct the problem, even with the assistance of a Hughes technical representative. When the unit arrived at the depot, it was subjected to extensive troubleshooting (two days on the depot's LRU test equipment) and the depot technicians finally were able to duplicate the faults detected by the Bitburg technicians. After replacing three shop replaceable units (SRUs), the unit was installed on the subsystem bench and ran extensively to verify the corrective action.

The LRU was then returned to the field. In an attempt to follow up on the performance of the unit, a note was placed on the serviceable condition tag asking the receiving unit to contact the depot if they experienced any problems with the LRU. (If all F-15 bases had a PORTER-like capability, such tracking could occur almost automatically.) The F-15 unit at Kadena Air Base, Okinawa, contacted the depot and informed them they had received the transmitter and had experienced the same failure modes on the unit that Bitburg and the depot had detected. The unit was returned to the depot for further work.

Although this LRU was still plagued by one or more faults, the PORTER prototype contributed by identifying this unit as one that needed the kind of special attention that the depot devoted to it. The problem with such units may be one that the fault is beyond the detection capability of the depot's equipment. For the longer term, both the Air Force and Hughes are exploring ways to bolster the depot's test capabilities, especially for faults that are sensitive to the flight environment. At this point PORTER can be viewed as a success by providing a way to break an LRU'S vicious cycle of circulating between avionics shops and airplanes, degrading combat capabilities, and wasting maintenance resources. Of course, ultimate success occurs when a unit is fully restored to deliver its designed capabilities. In the meanwhile the unit will be in the hands of those who have the best opportunity to help it rather than in an aircraft degrading the capability of an important weapon system.

The PORTER prototype showed initial benefits to the maintenance technicians, in terms of giving them an ability to quickly identify bad actor LRUs and remove those units from the base and send them to the depot for more extensive testing. The depot also benefits because they are receiving a copy of the PORTER generated history of the LRU instead of a condition tag containing a brief statement of the LRU's current problem.

Implementing Serial Number Tracking for Avionics

The Air Force is currently in the process of implementing CAMS throughout the Air Force's maintenance organizations. The challenge to implementing a PORTER capability into the maintenance process will be to interface/integrate that capability with CAMS to avoid duplication of data entry tasks and equipment. Two architectures are proposed that could accomplish this goal:

(1) One way to meet this challenge is to use personal computers (PCs) to simultaneously provide PORTER capabilities and data entry/extraction terminals for CAMS. The PCs could be placed at the seven locations, as they were with the prototype at Bitburg: pilot debriefing (three locations, one for each squadron), flight-line maintenance (three locations, one for each squadron), and the avionics shop. For the F-15 shop, it probably would be worthwhile to have three PCs: one for Automatic Test Stations, one for Manual Test Stations, and one for the F-15 TEWS (Tactical Electronic Warfare System) Intermediate Test Equipment. The PCs at all these locations would need to communicate with one another and with the CAMS software that is now hosted on a mainframe computer.

(2) Another way to meet the challenge is to build the PORTER capability into the CAMS software that would be hosted at a centralized location. With this architecture, user locations could be served by dumb terminals. There would be no need for PCs. There would be no need for maintaining PC software. There would be no need for communication links other than the direct links to the CAMS centralized location.

The time required to develop a PORTER capability in the CAMS software, given the ongoing workload of the CAMS program office, leads to a third possible architecture. This approach would incorporate as much of the PORTER capability as possible within the current CAMS architecture. The potential advantage of this approach is that it would give the Air Force a

nearly immediate capability. The prospective disadvantage is that only a small portion of the PORTER capability may be provided. Three questions remain to be answered:

(1) How much of the PORTER concept can be delivered quickly by merely adding an analysis package and retrievals to the current version of CAMS?

(2) How far does such a quick mechanization go towards giving the Air Force the information management capability that it needs to identify and repair bad actor equipment effectively?

(3) Is further progress needed?

Conclusions

The next decades will see growing demands placed on pilots of combat airplanes. To acquire, track, and destroy the highest priority targets, they will need highly capable weapon systems. To provide such systems, the Air Force will have to increase their functional performance by relying on additional amounts of aviation electronics (avionics) equipment that will become increasingly more sophisticated. Yet this reliance on such sophisticated equipment—and on complex integrations among such equipment—will make high reliability and ease of maintenance increasingly difficult to achieve.

Many factors that drive the avionics reliability and maintainability (R&M) challenges confronting the Air Force's fighter airplanes also drive the R&M challenges confronting other mobile military systems. These factors include (1) performance specifications that lead to complex applications of advanced technologies in highly integrated collections of subsystems; (2) designs that must satisfy tight space, weight, power, and cooling constraints; (3) an operating environment that includes extremes in thermal and dynamic loads; (4) a peacetime use that emphasizes accomplishment of training events that only partially replicate wartime needs; and (5) a multiple level support process with different test equipment and different tests at each level. Although this proposal for serial number tracking of avionics equipment is derived almost exclusively from research for fighter airplanes like the F-15 and F-16, it should prove beneficial to other kinds of aircraft that rely heavily on sophisticated avionics to perform their wartime mission, as well as to other mobile military systems such as helicopters and tanks that also rely on complex electronics.

Serial number tracking is currently used in several systems on Air Force aircraft. Engine modules and components of the F-15 and F-16 fighters are serially tracked for warranty validation. Components of egress systems on aircraft are also serially tracked to ensure the integrity of that critical life support system. Serial number tracking is also necessary for avionics equipment to ensure the critical avionics subsystems on modern combat aircraft will deliver their full designed capability.

Even with the advent of new technologies and even with the implementation of R&M improvements, there will always be some faults that escape prompt detection and correction at avionics shops and in depots. Prolonged cycling of such faulty equipment between shops and aircraft can be eliminated only with an effective serial number tracking program.

Notes

[1]This paper is based upon some results from RAND research performed under Project AIR FORCE and reported in *A Strategy for Reforming Avionics Acquisition and Support*, by J. R. Gebman and H. L. Shulman, with C. L. Batten, The RAND Corporation, R-2908/2-AF, July 1988; and summarized in *Executive Summary*, R-2908/1-AF, July 1988. A proposal to implement serial number tracking is one of six proposals constituting a comprehensive strategy for strengthening the Air Force's processes for acquiring and supporting avionics.

[2]The F-16 Centralized Data System has a capability to capture such information and to make it available at the flight line and the depot.

[3]In addition to a capability to access such information, the depot also needs to establish procedures for using such information. In the case of the F-16 radar, the depot already has access to some of the needed information via the F-16 Centralized Data System. Such information, however, was not being used by the depot during the 1984 data collection phase of the F-15/F-16 Radar R&M Improvement Program.

[4]After flying an aircraft, the pilot will report flight readiness status for the aircraft and major subsystems. Code 1 means that the pilot is reporting no additional discrepancies and therefore the aircraft or subsystem is still flyable. Code 2 means that the pilot is reporting minor discrepancies, but the aircraft or subsystem is capable of further mission assignment within normal turnaround time. Code 3 means the pilot is reporting major discrepancies in mission essential equipment that may require extensive repair or replacement before further mission assignment. See USAF Multi Command Regulation 66-5, *Combat Oriented Maintenance Organization*, paragraph 3-7e, for further details.

[5]Recent models of combat aircraft are featuring the capability to transfer data to and from the aircraft via a cartridge containing a magnetic tape. Such a data transfer unit for the F-16 C/D aircraft is capturing in-flight information for faults detected by the BIT. This creates the opportunity to free the pilot from having to write this information on a form.

[6]The Air Force has already sponsored the exploratory development of one such interactive debriefing capability that is hosted by a personal computer. This exploratory effort is beginning to illustrate the potential feasibility and value of the concept. Further work needs to explore ways to refine the approach and to streamline the interface with the pilot.

A Lemon by Any Other Name

This spring, Tactical Air Command (TAC) and Air Force Logistics Command (AFLC) hammered out a plan for dealing with bad actor line replaceable units (LRUs) based in part on the AFLMC's Bad Actor Management Study and on a lot of hard work by the HQ TAC and HQ AFLC staffs. The plan will affect all the weapon systems in the tactical air forces and will undoubtedly become the basis for an Air Force-wide bad actor program. As part of the plan, the term "Pacer Actor" will be used instead of "Bad Actor" to refer to problem LRUs to avoid prejudicial treatment of bad actors that have been repaired by AFLC.

In addition, the AFLMC is working three follow-on projects from the Bad Actor Management Study. The first is to make changes to TO 00-35D-54 (USAF Materiel Deficiency Reporting and Investigating System) to facilitate bad (pacer) actor handling under the TAC/AFLC plan. The second is an examination of how the Core Automated Maintenance System (CAMS) can be used for the identification and management of bad actors which addresses some of the questions raised in the Bad Actor Management Study and reiterated in Jean Gebman's and Major Jeff Snyder's article. The objective of the third is to draft new (or revise existing) Air Force regulations to provide guidance for the implementation of bad actor management programs.

Khe Sanh and the Logistics of Siege

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On 21 January 1968, 6,000 men at the Khe Sanh Combat Base (KSCB) were surrounded by North Vietnamese Army (NVA) forces. The battle at Khe Sanh raged for 77 days before Allied forces broke through enemy lines and the NVA retreated. (7:132-144) Meanwhile, United States (US) airpower engaged the enemy and kept the base supplied. Khe Sanh was totally dependent on airpower for its existence. (2:305)

Background

The Khe Sanh Combat Base was located near highway 9 in the I Corps Tactical Zone of South Vietnam, approximately 18 miles south of the Demilitarized Zone (DMZ) and 8 miles east of the Laotian border in Quang Tri Province. Established in 1962 as a Special Forces base, Khe Sanh had developed into a strategic operations center for reconnaissance flights over the Ho Chi Minh Trail and clandestine operations in Laos. (6:234) With increased NVA infiltration into South Vietnam along Route 9 in 1966, a small dirt airstrip was surfaced at Khe Sanh for use by helicopters and transport aircraft. (7:8)

Khe Sanh was used as a base for cutting off NVA infiltration into South Vietnam.

Khe Sanh was of strategic importance because of the airfield and because of its location along Route 9 which paralleled the DMZ. (6:234) Situated along the only major road in the area and surrounded by rugged mountains and dense jungle, Khe Sanh was used as a base for cutting off NVA infiltration into South Vietnam. (2:305)

The siege of Khe Sanh began in the late hours of 21 January 1968 and ended officially 8 April 1968.

At 2030 on 2 January 1968, a sentry dog alerted the guards. Six NVA, dressed as Marines, were seen approaching the post. Five were killed; the sixth was wounded but escaped. The five dead were all officers, giving an indication of the importance of the impending attack. (7:30) US military intelligence had reported NVA force buildup in the Khe Sanh area since mid-1967. The siege of Khe Sanh began in the late hours of 21 January 1968 and ended officially 8 April 1968. It is believed that Khe Sanh was used as a diversion for the TET offensive for which a cease fire was originally scheduled for 72 hours, but later cut to 36 hours for the Vietnamese Lunar New Year. (5:198)

The Khe Sanh defense force was composed of the United States Marine Corps 1st Battalion, 26th Marine Regiment, which was reinforced with battalions from the Ninth and 13th Marine Regiments and the South Vietnamese 37th Ranger Battalion. (9:216) Because the Khe Sanh airlift resupply requirement was already so large, artillery support was not available from the main base. The US Army's 2d Battalion, 94th Artillery at Camp Carroll, armed with 175-mm guns, provided artillery support. (2:306) Throughout the siege, Khe Sanh was resupplied by air and the enemy was barraged by close air support.

Military intelligence indicated the NVA 325C Division was northwest of Khe Sanh; the 304th Division was southwest; and elements of the 324th and 320th Divisions were available to provide reinforcements—an estimated 25,000 to 40,000 NVA regulars. (6:235) The NVA force included six infantry regiments, two artillery regiments, an unknown number of tanks, plus support and service units (7:29), and an anti-aircraft unit with 37-mm radar-guided guns. (11:80)

On 6 February, the Army Special Forces camp, Lang Vei, was overrun by NVA supported by artillery and nine Soviet PT-76 tanks, the communist's first use of tanks in South Vietnam. (9:217)

The final toll recorded was 205 American Marines dead and 1,602 North Vietnamese bodies left on the battlefield with dead estimated between 10,000 to 15,000.

The 1st US Cavalry Division, reinforced with elements of the First Marine Division and the South Vietnamese Airborne Brigade, began a relief operation termed Operation Pegasus on 1 April and, after hard fighting, the siege was finally lifted when the US Army's Second Battalion, Seventh Cavalry, linked up with the Marines at Khe Sanh. (9:217)

The final toll recorded was 205 American Marines dead and 1,602 North Vietnamese bodies left on the battlefield with dead estimated between 10,000 to 15,000. (9:217)

The defense of Khe Sanh involved several locations initially, including the main base, the village of Khe Sanh, and up to nine hill outposts. (7:50) As combat intensity grew, some outposts were abandoned and the village evacuated. The final defenses at Khe Sanh were the main base and Hills 558, 861, 881S, and 950. (2:308)

Historical Events at Khe Sanh (1962-1968)

	1962
Aug	U.S. Army Special Forces/Civilian Irregular Defense Group (CIDG) Camp established at Khe Sanh.
	1966
Oct	U.S. Marines 1st Battalion, 3rd Regiment, occupies Khe Sanh Combat Base. CIDG moves to Lang Vei.
	1967
Apr through Aug	Several "Hill Fights" between Marines and NVA forces. Increased enemy contacts spur buildup of US forces in I Corps Tactical Zone (ICTZ).
Sept	Khe Sanh airfield closes to normal traffic for runway repair. Opens to C-123 17 October.
1 Nov	Operation SCOTLAND I begins--defense of KSCB.
Dec	Patrols discover evidence of enemy buildup around KSCB.
	1968
2 Jan	Five NVA officers killed near western end of perimeter.
16-17 Jan	Reinforcements arrive from 26th Marines and Air Support Radar Team relocates to KSCB to handle ground controlled radar bombing missions.
	Reconnaissance team ambushed near Hill 881N.
19 Jan	Patrol searching ambush site is fired on, calls in for artillery attacks, and withdraws. Two platoons helilifted to Hill 881S as reinforcements for sweep toward Hill 881N the next day.
20 Jan	Marines attack NVA battalion entrenched on slopes of Hill 881N; 7 Marines and 103 NVA killed in action (KIA).
	NVA Lieutenant is captured; warns enemy attack is imminent. Reinforcements sent to Hill 881S and base placed on Red Alert.
21 Jan	NVA forces attack Hill 861 and penetrate southwestern perimeter before repulsed; 47 NVA dead.
	KSCB under heavy mortar, artillery, and rocket attack which destroys main ammunition dump. NVA forces attack and partially overrun Khe Sanh village. After second attack, defenders withdraw to confines of KSCB.
22 Jan	ComUSMACV initiates Operation NIAGARA to provide massive air support for Khe Sanh.
	Reinforcements arrive and take up positions which encompass the rock quarry southwest of KSCB. Forces relocate from Hill 558 to Hill 861A.
23-28 Jan	Civilian refugees evacuate Khe Sanh area to avoid hostile fire.
27 Jan	37th ARVN Ranger Battalion arrives KSCB and takes up positions in eastern sector of base.
30 Jan	TET offensive launched.

5 Feb	NVA forces attack Hill 861A in conjunction with heavy shelling of KSCB;7 Marines and 109 NVA KIA.
6-7 Feb	Special Forces Camp at Lang Vei overrun by enemy supported by PT-76 tanks; first use of NVA tanks in South Vietnam.
8 Feb	Approximately 3,000 personnel move overland from Lang Vei to Khe Sanh. After being searched and processed, several hundred refugees are air evacuated.
	Marine outpost 500 yards west of perimeter hit and partially overrun by NVA. During the three-hour battle, reinforcements with aid of supporting arms drive NVA from Marine position; 150 NVA KIA. Determination made to abandon outpost. Units withdraw to perimeter.
10 Feb	Marine C-130 hit by enemy fire during approach; crashes after landing; 6 killed.
Feb through April	Paradrops, low-altitude extraction systems, and helicopters are primary means of resupplying 26th Marines due to bad weather and enemy fire.
23 Feb	KSCB receives record number of incoming rounds for a single day—1,307.
	First appearance of enemy trench system around KSCB.
6 Mar	USAF C-123 shot down east of runway; 43 USMC, 4 USAF, and 1 USN personnel killed.
7 Mar	Large groups of refugees filter into KSCB and are evacuated.
15 Mar	American intelligence identifies withdrawal of major NVA units from Khe Sanh area.
25 Mar	1st ACD begins reconnaissance in force operations east of Khe Sanh in preparation for Operation PEGASUS.
30 Mar	Operation SCOTLAND I terminates with 1,602 confirmed NVA and 205 Marines KIA.
1 Apr	Operation PEGASUS begins.
6 Apr	3d ARVN Airborne Task Force airlifted to Khe Sanh. Elements of 1st U.S. Air Cavalry Division relieve Marines on Hill 471.
8 Apr	Official relief of KSCB.
11 Apr	Engineers complete restoration of Route 9 and road is officially opened.
15 Apr	Operation PEGASUS terminates.
23 May	President Johnson presents the Presidential Unit Citation to 26th Marines and supporting units during White House ceremony.
Jun	KSCB dismantled and abandoned. (7:180-186)

Logistics Support

Logistical support of Khe Sanh depended on airlift for the duration of the siege. The Marines were cut off from the supply bases at Dong Ha and Quangtri. Cargo planes and helicopters kept the base supplied. (6:235)

As the situation developed, General William M. Momyer, the Commander of 7th Air Force, presented Operation Niagara to the US Military Assistance Command, Vietnam (USMACV). The plan called for the Commander, 7th Air Force, to be assigned complete control and authority over all airpower in the area of Khe Sanh. At the time, seven separate air arms were operating in-country. (11:80-81) USMACV approved the plan and Operation Niagara commenced.

Operation Niagara was a joint US Air Force, Navy, and Marine Corps air campaign throughout the siege which employed the massive firepower available, using sensors installed along the DMZ and reconnaissance flights to pinpoint targets. The operation also included pinpointing the enemy, using Marine patrols, air reconnaissance, radio intercepts, radar, and ground sensors. Once located, artillery and bombs would be directed at the enemy. (6:235) In support of Operation Niagara, an armada of 2,000 aircraft and 3,300 helicopters was organized to pulverize NVA troops in an unprecedented artillery bombardment. (3:81)

Approximately 9,700 tactical fighter-bomber sorties, 7,000 Marine air sorties, 5,000 Navy aviation sorties, and 2,500 B-52 strategic bombing sorties were flown delivering more than 110,000 tons of bombs (9:266) and 700,000 rounds of aerial cannon and machine-gun fire. The ordnance was expended in

support of a defensive plan agreed on with the Marines. B-52s were directed to targets beyond 1,100 meters from the perimeter, tactical air and artillery were to cover 250 to 1,100 meters from the perimeter, and small arms and mortars were to fire on targets less than 250 meters. (11:81) B-52s were used against suspected staging areas for tanks which were expected to be used to overcome Khe Sanh defenses. (2:310) Air support provided round-the-clock shelling and bombing. Groups of three B-52s left Guam and Thailand every three hours and were over Khe Sanh every hour and a half. (3:81) The Marines used 105 and 155 Howitzers, plus mortars and 106-mm recoilless rifles. The Army added 16 tubes of 175-mm guns, hurling 7-inch shells 20 miles. (5:208) Seismic sensors were dropped on the approaches to the base. An airborne EC-121 relayed the sensor information to Dong Ha. Strike aircraft were then directed into the area. (2:309)

Supplying Khe Sanh was primarily the responsibility of the 834th Air Division of 7th Air Force. Initially, daily supply requirements were unknown due to the unpredictability of the length of the siege or rate of escalation. The support planners used three criteria for the resupply effort: guarantee uninterrupted aerial resupply, minimize vulnerability of delivery aircraft and aircrews, and minimize problems of load recovery. (11:82) A firm figure for resupply requirements was established after the first two weeks. (11:83) Initially, approximately 60 tons per day was required, but the resupply effort grew to 185 tons per day for the five battalions at Khe Sanh. (11:83)

The major supplies required by the forces at Khe Sanh included tons of fortification materials, fuel, tires, barbed wire, and spare parts. Ammunition held top priority for airlift resources, followed by rations, mail, and casualty evacuation. (7:90) Efforts were made to maintain a 20-day supply of ammunition and rations at Khe Sanh. Records indicate a 21-day supply was available. As the siege progressed, variations in supply requirements complicated support efforts. Nearly all classes of supply were in demand. About 25% of the supply requirement through the end of January was Class IV, fortification materials. Toward the end of the battle, this requirement dropped to around 13%. Class II supplies were eventually eliminated from the effort. Ammunition, Class V, required over 50% of the airlift in March. (11:84)

The troops at the main base received two C-rations a day, occasionally supplemented with juice, pastry, hot soup, or fresh fruit. The men at hill outposts subsisted almost entirely on C-rations with time between meals dependent on the weather. Within the compound, water was only rationed when the pump was inoperable. Hill 558 was flanked by two streams; however, the other outposts were dependent on helilifts for water supplies. (7:90)

Medical attention was provided immediately. Minor wounds were treated at the battalion aid stations and the injured returned to duty. More serious injuries were treated at "Charley Med," a detachment just south of the aircraft loading ramp. US Navy doctors and corpsmen treated the wounded, performed surgery, and prepared cases for medical evacuation. During the siege, 825 personnel were treated (7:93) with 306 evacuated. (11:84)

Obstacles of the aerial resupply effort were terrain, weather, and enemy fire. The airfield was 1,500 feet above sea level, surrounded by the enemy and by mountains. The runway was 3,900 feet long and 60 feet wide with no taxiway. Due to the small size of the defense perimeter and the close proximity of the troops to the airfield, a drop zone outside the defense perimeter was used in the resupply efforts. (11:83-85)

The job of transporting enough "beans, bullets, and bandages" for the 6,680 Khe Sanh defenders was complicated by the poor visibility and heavy antiaircraft and artillery fire directed at incoming transports. C-130s were particularly vulnerable targets and, for a time, the airfield was closed to C-130s, relying on C-123s and helicopters for resupply. Several techniques for fast off-loading were used, including the low altitude parachute extraction system (LAPES), paradrops, and the ground proximity extraction (GPE) system. During the siege, 52 LAPES and 15 GPEs were made. (7:72-90)

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Helicopters flew daily missions delivering supplies, delicate cargo, and reinforcements, and evacuating casualties. Since the helicopters were slower than the fixed-wing transports, vulnerability to enemy ground fire was greater. The helicopters operating primarily from Quangtri and Dong Ha were reinforced from the main base at Phu Bai. The pilots and crewmen flew Huey gunships, CH-46 transports, and UH-34s. Additionally, CH-53s of Da Nang made a sizable contribution to sustaining Khe Sanh because of their heavy payload. (7:80)

The resupply of hill outposts relied on helicopters. About 20% of the Khe Sanh defense force was positioned at the outposts, essentially cut off from the rest of the garrison. The weather often precluded resupply and some outposts went without resupply for days at a time. The NVA took advantage of the cloud cover and placed automatic weapons on peaks around the outposts creating further threat to the helicopters during each mission. (7:85)

In response, Operation "Super Gaggle" was organized. Twelve A-4s, one TA-4, twelve CH-46s, and four UH-1E gunships were involved in each mission. The A-4s would launch from Chu Lai, while 12 to 16 helicopters simultaneously launched from Quangtri and proceeded to Dong Ha for supply pickup. Each aircraft would arrive at the designated area on a precise schedule. The general schedule followed this pattern: four A-4s coverd known enemy positions armed with napalm and bombs; two A-4s saturated enemy antiaircraft and automatic weapon positions with tear gas; and two A-4s provided a smoke screen along approach paths just 30 to 40 seconds prior to the final run by the helicopters. While the helicopters made their approach to the target, four A-4s with bombs, rockets, and 20-mm guns provided close-in fire suppression. The Huey gunships followed closely to pick up any downed crews. (7:85-86)

The weather in this part of Vietnam is affected by both the southwestern and northeastern monsoons. In January and

February, Khe Sanh expected low clouds in the mornings with visibility of one to two miles and a ceiling of 500 to 1,000 feet.

Weather frequently isolated the outposts.

In late morning, the clouds would break and conditions improve; but by late afternoon, the weather deteriorated (2:306), restricting air operations to a relatively short period when visibility was suitable for air strikes and parachute deliveries. (4:56) Because of the weather, all B-52 attacks and 50% to 60% of other air attacks were under control of a radar bomb facility. (2:310) Weather frequently isolated the outposts. (4:56) The weather during February was considered bad for operations but not uncomfortable. The average temperature was 71 degrees, average humidity 92%, and average weekly rainfall .04 inches. The wind was predominately out of the east at 6 mph. (4:72)

Refugee evacuation was a major undertaking throughout the siege. The population of Quang Tri Province was recorded in July 1963 to be 252,632. The area in the boundaries of the province was 4,261 square kilometers. (8:100) The first noncombatants began to appear when the Khe Sanh village was

Refugee evacuation was a major undertaking throughout the siege.

abandoned on 23 January. The few refugees were evacuated in planes which had unloaded at Khe Sanh. As the enemy occupation of the area increased, additional civilians flowed into the base. The situation was complicated by the limited space on the Khe Sanh plateau, the possibility of enemy fire, and by NVA and Viet Cong infiltration. (4:26)

The airlift effort succeeded in delivering 8,120 tons of cargo by parachute in 601 sorties by C-130s and C-123s. C-130s landed 273 times, C-123s 179 times, and C-7s 8 times to deliver 2,676 passengers and 4,310 tons of cargo while transporting 1,574 people out of Khe Sanh. The number of supply drops made at Khe Sanh from 21 January to 15 March exceeded the total for all of Vietnam prior to that time. (4:58)

Lessons Learned

The defense of Khe Sanh was considered a major success by the US military forces in Vietnam although political and public opinion was completely the opposite. So, it can reasonably be said that the NVA achieved their objectives in attacking Khe Sanh. The first objective was to provide a diversion for the TET offensive. The primary objective, though, was to score a psychological defeat of the American public similar to the French defeat at Dien Ben Phu in 1954, leading to withdrawal from the war. (1:231) Many lessons are associated with the battle for Khe Sanh.

Most importantly, interservice cooperation is essential to the sustainability of forces isolated by the enemy. Due to the structure of US military forces, coordination and control of air assets between the services became a necessity both because of the limited resources of each service and the restricted capabilities of each type of aircraft. As limited as the airspace was over Khe Sanh, a cooperative effort was important, as evidenced throughout Operation "Super Gaggle." Without escort aircraft, the helicopters could have been destroyed and our forces annihilated.

Secondly, never underestimate the enemy. Popular opinion held that the NVA and Viet Cong would not risk alienating the South Vietnamese people by violating the sacred Vietnamese lunar new year. The use of Khe Sanh as a diversion was effective and most of South Vietnam was unprepared for the TET offensive.

Close coordination with the media, although potentially trying, is essential to accurate reporting. At the time of Khe Sanh, a media corps approaching 1,000 people and reflecting every shade of world opinion was in Saigon. (5:198) One of the main faults of the public affairs associated with the events at Khe Sanh stemmed from the inaccurate reports provided to the media. Throughout the Vietnam War, reporters were provided stories and hunted other stories down. While some of the reports were based on observed events, most were based on the information provided by the military public affairs officers or from overheard conversations. It has frequently been said that the media lost the war. The military cannot censor all details and the information provided the media must be accurate. (10:70)

Khe Sanh was often compared to General Custer and the Battle of the Little Big Horn. By using the resources available to them, the defenders held the base. Lessons learned at Khe Sanh are evident in military planning and training today. Close air support and use of helicopters are of primary importance. In future "wars without fronts," cargo delivery techniques could be vital. The significance of interservice cooperation (joint operations) must be recognized. To support ground forces in the future, both helicopters and fixed-wing airlift aircraft will be required.

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Transportation Combat Readiness and Resources Branch

Within the next few months, the base level Transportation Combat Readiness and Resources Branch (formerly Transportation Plans and Programs) will receive established manpower standards and formal guidance in the form of an Air Force regulation. These standards and workload factors are now at the MAJCOMs for coordination. The Air Staff has quantified training requirements for assigned personnel, and manpower and other funding requirements for this training are now being identified. Once formal guidance is distributed and unit manpower documents adjusted, the typical base transportation squadron will have a specific branch to perform war planning, readiness training, and resource management functions. Personnel assigned to this branch will continue to carry their original transportation AFSCs. The training and experience gained from planning and programming transportation requirements for war and peace will be very beneficial for grooming transportation's future leaders and managers. This branch will significantly improve unit level readiness both in wartime and peacetime exercises and more effectively address future resource needs—manpower, facilities, automated systems, and productivity. (Major Yamasaki, HQ AF/LETX, 227-7332)

ADPE Now A Player in Expense/Investment Criteria Policy Changes

If Air Force personnel did not see SAF/ACBM (14 Dec 88) and HQ USAF/SCP/ACB (10 Jan89) messages, then they need to be aware of Expense/Investment Criteria policy changes affecting automatic data processing equipment (ADPE) procurement. They may be budgeting for ADPE requirements in the wrong appropriation and budget program. The threshold for locally purchased equipment has been increased from $5,000 to $15,000, and the cost basis must be reflective of the total system vice individual components. When Congressional actions mandated these changes for FY 1989, adequate information was not readily available to make the transition for ADPE. Also, immediate application of the new threshold and across-the-board realignment of ADPE programs was further complicated by a lack of clarity regarding what actually qualified as a system. During the FY 1990/91 President Bush budget revision, the Office of the Secretary of Defense (OSD) issued a Program Budget Decision (PBD) that adjusted affected programs and transferred funds from 3400 to 3080 appropriations (Operations and Maintenance to Other Procurement Air Force). The PBD also adjusted FY 1992 through FY 1994 funds based on command projections. Any further controversy over what constitutes a system will be alleviated by DOD Instruction (DODI) 7040.5 which contains these policies. An updated version of the DODI is currently in draft with final publication expected in January 1990. (Ms Jones, HQ AF/LEXP, AUTOVON 225-7031)

Standard Tools for Aeronautical Repair (STAR)

The Air Force is implementing two lists which define the common hand tools desired for future maintenance. The Standard Tools for Aeronautical Repair (STAR) list contains 127 items and defines those tools used for organizational and intermediate level maintenance of aircraft, aircraft engines, and related support equipment. It will be used during the acquisition process to measure a contractor's ability and willingness to develop systems which are maintainable primarily with tools used by the Air Force. The Standard Tools for Aeronautical Removal and Replacement (STAR^2) list contains 54 items and defines those tools used for on-equipment maintenance. Its use will be mandatory. Systems design and on-equipment maintenance concepts must be consistent with the STAR^2 list. Procedures for the STAR and STAR^2 lists are being incorporated into Air Force 800 series regulations. Both lists are accessible now to DOD and civilian agencies through the automated Support Equipment Acquisition Management System. (CMSgt Jim Chambers, AF/LEYY, AUTOVON 227-1177)

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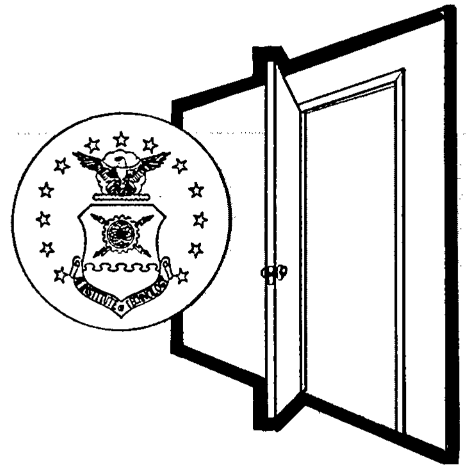
SPECIAL ON THE KOREAN WAR

AFIT



The Doorway to Logistics Success

AFIT Checkpoints

RESEARCH DIRECTOR - Lieutenant Colonel Larry Emmelhainz of the Department of Logistics Management has been appointed as the Director of Research and Consulting for the School of Systems and Logistics. As the first such title holder, it will be Colonel Emmelhainz's job to coordinate research and consulting activities within the school and to act as the initial point of contact for units desiring to sponsor student or faculty research, or call on faculty members for consulting assistance. Colonel Emmelhainz can be reached at AUTOVON 785-2061/2063 or commercial number (513) 255-2061/2063. Mail should be addressed to him at AFIT/LSC, Wright-Patterson AFB OH 45433-6583. He looks forward to hearing from you.

CONSULTING PROJECT - Lieutenant Colonel Dick Moore has been working as a member of the Wright-Patterson Medical Center's Pharmacy Process Action Team (PAT). This team was established as a part of the Medical Center's Quality Program to reduce the up to two-hour delay involved in filling a prescription. With a military population of 11,000 and a large number of retirees, the pharmacy at Wright-Patterson is a very big operation which processes approximately 2,500 prescriptions daily. The improvement effort focused on reducing prescription queue time in the filling process. Waiting for the various steps in processing accounted for over 90% of the customer's overall wait, and queues were primarily the result of workload distribution and line balancing problems. Using his background in Operations Management, Colonel Moore was able to redesign the work flow of the pharmacies and, through the Med Center's Quality Management Program, get the plan implemented. While preliminary results have been impressive—maximum wait times cut in half and average customer wait being continually reduced—the prescription computer system remains a bottleneck in the operation. The system software—which runs on a Z-248 and was designed for much smaller operations—is severely taxed when used to handle the prescription volume at a major medical center. Therefore, in addition to continual improvements in process flow, computer upgrade is a major item on the Pharmacy PAT's weekly agenda. AFIT faculty are available for such consulting efforts Air Force wide contingent on their course load and the availability of TDY funds.

MICROCOMPUTER EDUCATION - Over the past several years, the School of Systems and Logistics has undergone a major change in the way it approaches computer education. Four years ago, students used one of AFIT's Digital Equipment Corporation VAX 11/785s for statistics, simulation, and FORTRAN programming, as well as a nonstandard Burroughs microcomputer for word processing. This approach led to graduates who, although proficient in computer use at AFIT, had great difficulty in applying their new knowledge in the environment faced by operational logisticians. This problem was brought to the attention of the school by both new faculty, who were accustomed to an MS-DOS applications oriented environment during their Ph.D. programs, and even more forcefully, by recent graduates who found their new bosses' expectations did not line up well with their microcomputer capabilities.

The current philosophy of the school is to integrate MS-DOS computers into the curriculum, where appropriate, using software that the students can purchase at a reasonable price and take with them to their next assignment. New students are oriented to MS-DOS shortly after signing in and are provided the opportunity to purchase discounted computer systems and software at a computer fair hosted by the AFIT Association of Graduates each June. Their first micro-based course is built around Borland's spreadsheet, known as Quattro, and structured programming in Ashton-Tate's dBASE III PLUS programming language. In the two course statistics sequence, students use a PC package called Statistix II by NH Analytical Software, and their simulation work is done in Sierra Software's Simple 1. No specific word processing package is required although the Institute has standardized on Wordperfect 5.0 for administrative purposes and our students have access to it on the School's systems. This integrated instructional program is supported by two Z-248 equipped classrooms and three terminal rooms all with Z-248 capability. The program produces graduates who own and are proficient with a set of software that they can readily put to good use following graduation. The School of Systems and Logistics is now compatible with field level use of microcomputers and intends to stay that way in the future.

READER SURVEY

1. What is your current status?

A. Active USAF	**36.6%**	F. Other DOD Civil Service	2.0%
B. Air National Guard or USAF Reserve	6.0%	G. Non-DOD U.S. government employee	.5%
C. Other U.S. military	1.2%	H. Education	1.1%
D. Other national military	1.3%	I. Business/industry	2.1%
E. USAF Civil Service	**48.1%**	J. Other	1.0%

2. What is your rank/grade?

A. General officer	1.6%	G. GS-16 through GS-18	.1%
B. 0-4 through 0-6	**30.9%**	H. GS-13 through GS-15	**25.0%**
C. 0-1 through 0-3	7.9%	I. GS-9 through GS-12	21.2%
D. E-7 through E-9	2.6%	J. GS-1 through GS-8	1.7%
E. E-1 through E-6	3.1%	K. Wage Grade	.5%
F. Gov't civilian appointee	2.6%	L. Non-government employee	2.8%

3. Which major field best describes your current job assignment?

A. Supply	9.7%	I. Logistics & Engineering	**12.6%**
B. Maintenance	11.8%	J. Resource Management	9.0%
C. Contracting	2.4%	K. Operations	2.4%
D. Transportation	2.9%	L. Education/Training	5.3%
E. Logistics Analysis	4.6%	M. Research/Studies/Analysis	2.8%
F. Logistics Plans/Programs	**15.0%**	N. Other	8.6%
G. Systems Acquisition	5.5%		
H. Engineering & Services	6.3%		

4. How do you normally obtain the *AFJL*?

A. Official USAF distribution (PDO)	**57.8%**	D. AFLMC distribution	16.4%
B. GPO subscription	5.0%	E. Library	1.2%
C. OCPO distribution	11.7%	F. Coworker	2.3%
		G. Other	5.7%

5. How many readers do you estimate see your quarterly copy of the *AFJL*, or the one that is routed to you?

A. Only myself	11.7%	D. Eleven to fifteen	9.3%
B. One to five	**44.7%**	E. Sixteen or more	8.7%
C. Six to ten	22.2%	F. Do not know	3.3%

6A. How many copies of the *AFJL* are distributed to your duty section through official USAF channels?

A. Not eligible for official USAF distribution	3.4%
B. None	22.4%
C. One to four	**69.0%**
D. Five to nine	2.3%
E. Ten or more	2.9%

B. Are you satisfied with the number of copies of the *AFJL* distributed to your duty section through official USAF channels?

A. Not eligible for official USAF distribution	4.5%
B. No, too few	21.4%
C. Yes, just enough	**71.7%**
D. No, too many	2.4%

7. Thirty-six quarterly issues of the *AFJL* have been published. How mar issues have you seen?

A. This is the first	3.6%	C. Eleven to nineteen	33.4
B. Two to ten	**44.8%**	D. Twenty to thirty-six	18.2

8. How much of each issue do you usually read?

A. All	11.2%	D. One or two articles or departments	23.6
B. Most	**33.4%**	E. Very little	4.1
C. About half	25.5%	F. Look at but seldom read	2.3

Items 9-20 are discussed later.

21. Do you, or does your office or organization, retain back issues of the *AFJL*

A. Yes	60%	C. Do not know	9.6
B. No	**30.4%**		

22. Which of the following describes the value of the *AFJL* to you? (Select many as applicable) **1184 responses**

A. Have used some contents in my work/professional life	45.4%	D. Informative—usually learn some thing new from each issue	**56.8**
B. Some ideas/information may be useful in the future	37.4%	E. Interesting	38.0
C. Educational—increased my understanding of AF logistics	53.8%	F. Uninteresting	1.6
		G. No value	1.2

23. Do you agree or disagree that the *AFJL* meets its purpose: ". . . to provic an open forum for presentation of ideas, issues, research, and informatic of concern to logisticians. . . ."

A. Strongly agree	23%	D. Disagree	2.3
B. Agree	**67.4%**	E. Undecided	6.8
C. Strongly disagree	.5%		

24. How do you rate the *AFJL* in comparison with other logistics publications

A. The best	7.0%	D. Below average	2.1
B. Better than most	**52.6%**	E. I am not familiar with any other logistics publications	16.5
C. Average	21.8%		

25. What other regular departments or features would you like to have in th *AFJL*? (Select as many as applicable) **1067 responses**

A. Analytical Tips	36.3%	D. Other (Specify in Comments)	9.9
B. Book Reviews	28.4%	E. None—leave as is	23.5
C. Past Reflections (contributions by oldtimers)	30.4%		

26. Would you like to see more photographs in the *AFJL*?

A. Yes	**61.7%**	B. No	38.3

As of our survey *cutoff* date (2 Aug 89), we had received 1,217 responses out of approximately 9,000 surveys. As of publication date, we had received 1,291 responses.

An analysis of the responses indicates the Journal reaches its primary target readership (Questions 1 and 2), is a valuable and informative publication (Question 22), meets its purpose as a professional Air Force journal (Question 23), and is better than most other logistics publications (Question 24).

The INDEX TO U.S. GOVERNMENT PERIODICALS commented that the journal is "authoritative and current, has a variety of subjects presented in each issue, has excellent graphics, and is well suited for the audience for which it is intended."

Items 9 - 20

We received an overall "GOOD" for these items. However, several readers identified areas in which the Journal can improve (appearance and departments), and many readers suggested some potential topics for future articles:

(Appearance)

Beginning with this issue, we are using desktop publishing which will enable us to incorporate more eye-appealing techniques. We have used blow-ups, format changes, and larger print for some of the departments. We have also used more photos (Item 26). In addition, we plan to print larger and less complicated graphics. We are now limited to one color (10 pages including covers) but will request an increase in number of pages when our Publications Board meets next year.

(Departments)

Career and Personnel Information - Civilian readers wanted more detailed information on the LCCEP program, career broadening, educational opportunities, and future jobs. Military readers would like to see more indepth information on the military logistics career field growth or direction. Our contacts at AFMPC will expand their future inputs for these sections.

Reader Exchange - Readers want a more open forum or PRO/CON exchange. Since we depend on our audience for letters for this section, we need your help in submitting comments.

New Departments (Question 25) Readers would like to see regular departments on analytical tips, book reviews, and past reflections. We plan to include at least one book review in each Journal, starting with the Fall issue. We will feature analytical tips and past reflections in future issues, based on submissions from our readers.

(Suggested Topics)

1. Lessons Learned from Past Experiences/Problems
2. Air Logistics Center Operations and Problems
3. Total Quality Management
4. Reliability and Maintainability
5. Munitions
6. Future Systems Acquisition
7. Contracting
8. Budget
9. Low-Intensity Conflict
10. Mobility
11. Environmental Management
12. Space
13. Techniques in Industry Transferable to Military Ops
14. Foreign Military Assistance
15. Security Assistance

We encourage our readers who work in these areas to write articles for the Journal. REMEMBER—YOU READERS ARE OUR WRITERS.

We received the highest overall ratings for items 11 (Proofreading; Composition Accuracy), 13 (Article Quality), and 20 (Overall Relevance).

Personnel and organizations inside the Air Force can be placed on automatic distribution for the *AFJL* by notifying their local servicing PDO of their requirements for AFRP 400-1. If unable to use the PDO system, contact the editor. *AFJL* is also for sale by the Superintendent of Documents, US Government Printing Office, Washington, DC 20402. Instructions for submitting articles to the Journal are listed at bottom of Table of Contents page.

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and rotated through four major directorates (materiel management, maintenance, distribution, and procurement) for six months each. They are then assigned for their third year to a position in one of these directorates.

The LPDP is highly selective. Officers must have a history of superior performance and potential for promotion to senior-level logistics positions. Captains and majors can have no more than 12 years of total active federal military service. Officers are picked by their respective assignment teams and nominated to AFLC for final acceptance.

The LPDP provides selected officers with a well-rounded, wholesale logistics background. LPDP alumni are in continual demand.

This is just another opportunity to make your career in the Air Force a worthwhile and valuable experience.

If you are interested in the program, read AFR 400-30, *The Air Force Logistics Command (AFLC) Logistics Career Broadening Program*, complete a new AF Form 90, and give your assignment officer at AFMPC a call.

(Captain Ann Smith, AFMPC/DPMRSL1, 487-3556)

CAREER AND PERSONNEL INFORMATION

Civilian Career Management

LCCEP Referral Process

When a Logistics Civilian Career Enhancement (LCCEP) registrant is referred to an Air Force base to fill a vacancy (by a career program certificate), an extensive computerized screening process has occurred. The entire referral process begins when the base has a vacant LCCEP position and requests a list of candidates from the career program office at Randolph AFB, Texas, to fill that position. A member of the LCCEP PALACE Team reviews the Position Description (PD) for that particular job and then selects the appropriate Promotion Evaluation Pattern (PEP) used to rank candidates for the job.

That is when the computer goes to work. The Personnel Data System-Civilian (PDS-C) first screens all the LCCEP registrants' geographical availability codes to determine how many people would accept a reassignment/promotion at the base with the vacancy. Since registrants can update their geographical availability at any time, the listing of people willing to accept jobs at a particular location can vary on a month-to-month basis. This is why the computer must first screen for the geographical location each time a certificate is requested. Contrary to belief, the PALACE Team does not have a routine "list" of candidates for each series/grade.

Once the computer determines who will accept a position at that particular base, it will screen all those candidates' experience records to determine who has the right combination of skills codes for the job, as indicated in the PEP. The PEP, developed by a group of logisticians from various organizations in the Air Force, acts as a "funnel" to effectively separate the lesser qualified candidates from the most highly qualified candidates. If there are more than 15 highly qualified promotion candidates and more than 15 highly qualified reassignment candidates, the computer will use a series of tiebreakers to determine the top 15. The first tiebreaker is the civilian appraisal, the second the Cadre Interview Score (CIS), the third the civilian performance awards, and the fourth, and final tiebreaker, the Service Computation Date.

As the second tiebreaker, the CIS is used regardless if the candidate is a cadre member or not. The cadre member scores are used for three years (normal cadre tenure). Non-cadre member scores are used for one year. Those LCCEP registrants who decline cadre interviews are effectively precluding their chances of having that second tiebreaker! Situations have occurred where candidates with a CIS became the fifteenth candidate on a certificate, even though their CIS was not high enough to be in the cadre. With potentially everything to gain and nothing to lose, but maybe 30 minutes of interview time, LCCEP cadre applicants should seriously reconsider declining a cadre interview.

Once the four tiebreakers are applied, the out-of-town promotion candidates are contacted to determine if they will accept referral for that job. This process continues until a list of 15 promotion candidates is completed. That list, along with 15 reassignment candidates, is forwarded to the selecting supervisor. The rest is up to that individual, who will review career briefs and possibly conduct interviews. The LCCEP Program Office does not make the selection; rather, they only refer the best qualified registrants to the supervisor.

With this process in mind, it is extremely important that employees periodically check their career briefs for accuracy, as well as their geographic availability codes. Geographical location registration is not to be taken lightly since there are penalties for declinations. The computer only screens what is in a record; and, once the referral process begins, there is no capability for manual input. All changes to career briefs and geographic availability codes must be done by the employees' servicing Central Civilian Personnel Office (CCPO). Due to batch processing procedures between the base-level computer and the PDS-C, it can take up to 45 days for the PDS-C to reflect the updates. This means proactive record upkeep by individuals is especially important.

(Rita Fox, AFCPMC/DPCMLD, Randolph AFB TX, AV 487-5631)

Logistics Professional Development

Air Force Logistics Professional Development Program (LPDP)

The LPDP was established to develop a base of officers with experience in managing the wholesale aspects of the Air Force logistics system. Formerly called the AF Logistics Career Broadening Program, it was started in 1975 due to a lack of wholesale logistics experience in the officer force; there were simply not enough mid-level positions in air logistics centers (ALCs). Presently, there are 69 authorizations in 31XX, 40XX, 49XX, 60XX, 64XX, 65XX, and 66XX Air Force specialty codes. The specific goals are to put the "blue suit image" in the ALC environment, expand the base of officers with wholesale logistics experience, and provide future executive level manager candidates for top logistics positions. Air Force Logistics Command (AFLC) and Air Force Military Personnel Center (AFMPC) have overall responsibility for the program.

Officers are assigned to either HQ AFLC, one of the ALCs, or the Aerospace Guidance and Meteorology Center (AGMC)

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